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Ifremer

A Year of Ocean Sciences

2021

2022

From the abyss to the surface, from the coast to the high seas, Ifremer is the only French research institute entirely dedicated to the Ocean.

A Year of Ocean Sciences
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A better understanding of the last unexplored places

Bruno Bonell, Secretary General for Investment

© Secretary General for Investment

Today's oceans face many challenges. Our country has the world's second largest maritime area, spread across three major oceans: Atlantic, Pacific, and Indian. The deep ocean, where depths exceed 200m, cover two-thirds of the Earth's surface, but only a very small fraction has been explored to date. Yet they harbour a rich biodiversity and interact with our climate. Understanding these environments will be a source of major scientific discoveries. It is also an issue of sovereignty. That's why deep-sea exploration is one of the ten objectives of France 2030, the €54 billion investment plan launched in October 2021 by the French government to transform the strategic sectors of our economy through innovation, research, industrialisation, and training. With France 2030, 350 million will be invested in scientific knowledge of the deep seabed. This is unprecedented, and reflects a growing awareness of the importance of the challenges facing the ocean, which is reflected in the extensive involvement of the French government.

We have a number of ambitions: to strengthen scientific research, support innovation specific to the deep ocean, conduct exploration expeditions to gather scientific knowledge of the deep ocean using innovative equipment supplied by the French industry, but also disseminate knowledge and carry out awareness-raising initiatives aimed at the general public.

As a cutting-edge institute, Ifremer is a key player in contributing to our scientific knowledge of the deep seabed, in particular by carrying out exploration campaigns at sea, and a catalyst for innovative projects with industry.

I would like to take this opportunity to welcome the first operational use of UlyX, a new-generation drone capable of diving to a depth of 6,000 metres. As we know, the ocean is an ecosystem under threat from global warming, pollution, and over-exploitation of its resources. The Ocean-Climate priority research programme (PRP), co-directed by the French CNRS (French National Centre for Scientific Research) and Ifremer, has been allocated €40m over 6 years (2022-2027) to improve our understanding of this environment and help preserve it. The various calls for projects launched are designed to pursue and develop the cutting-edge technologies needed to understand the seabed.

The establishment of a research programme (PERP) on the seabed, entrusted to the CNRS, Ifremer and the IRD, will study the physical, biogeochemical processes at work in the deep seabed in order to provide a wealth of data that will contribute to the global digital description of the ocean. This 2022 activity report highlights Ifremer's many achievements in research and innovation in the field of ocean sciences, and I am delighted to discover the great successes to and in the future, as we work towards a better understanding of this final frontier.

Editorial
Francois Houllier, Chief Executive Officer at Ifremer

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A high point in the life of a research organisation, the Hcéres evaluation praised the quality of the research conducted by our institute's laboratories, our ability to manage major research facilities, the scientific policy pursued since 2017 and the attention paid to overseas France. It noted the relaunch of an innovation approach based on the transfer and partnership with businesses, recognised the relevance of expert assessments and monitoring activities in support of public policies, and appreciated the efforts made to share marine knowledge with as many people as possible. These positive results are to the credit of Ifremer's employees and teams. The assessment also identified areas for improvement, which will be taken into account in the preparation of the next goals, resources, and performance contract. In particular, it highlighted the need to increase multidisciplinary nature in order to understand the major societal issues affecting the oceans and the dual need to strengthen Ifremer's economic model and improve the attractiveness of careers at the institute.

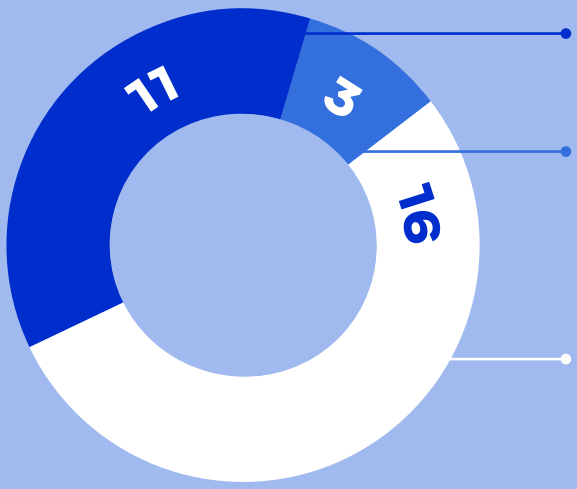
The year 2022 also saw the deployment, launch, and announcement of several programmes funded by France2030 that support the development of marine science and technology. Over the past few years, the General Secretariat for Investment and the Ministry of Higher Education and Research have launched a range of ocean-related initiatives that are not confined to the 'Objective 10' programme dedicated to the seabed. Many aspects of ocean sciences are covered, including priority research programmes, facilities of excellence, flagship projects, and developments to support the emergence of new sectors and France's technological sovereignty. Ifremer is involved in these programmes in three ways: not only through its units as a scientific and technological operator carrying out and participating in projects; but also in its role of programming research and building shared scientific facilities; and as a committed partner alongside several universities whose projects include a maritime section.

In February 2022, under the French presidency of the Council of the European Union, the first international summit dedicated to the ocean, the *One Ocean Summit*, was the first stage of major events which, throughout 2022, affirmed the importance of the ocean and the issues associated with it on the European and international agendas. The focus is now on the 3rd United Nations Ocean Conference, co-organised by Costa Rica and France and to be held in June 2025 in Nice: science is a set to play a major role and Ifremer is preparing to make a full contribution.

2022 Key figures

Research

640
scientific publications



Expertise

79
opinions or expert reports produced

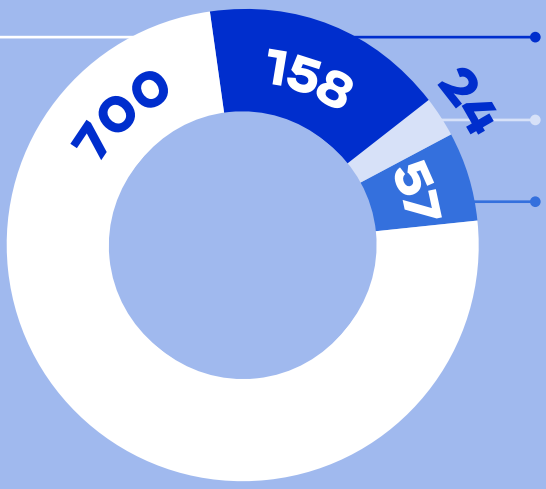
Innovation

5
invention statements

Human resources

1549
employees

Researchers and engineers, **105** are qualified with Accreditation to Supervise Research (HDR)



PhD students

Post-doctoral students

external recruitments in 2022

Budget

260,5
million euros
of expenditure

36,5
million euros
of investments

2022 Highlights

9-11 February

Mobilised at the *One Ocean Summit*

THE ONE PLANET SUMMIT FOR THE OCEAN
9, 10, 11 FEBRUARY 2022

Ifremer was heavily involved in this international summit on the ocean, which took place in Brest over 3 days, organising the OneOceanScience forum, a world tour of ocean sciences welcoming scientists from 10 countries, and a meeting of European oceanographic fleets) and taking part in other activities.

13 February

Nautile dives for the French Navy

The manned submarine Nautile carried out a four-hour dive in the Mediterranean to demonstrate the deep-sea intervention capabilities of the French Oceanographic fleet. Led by Ifremer, the dive enabled a specialist from the French Navy to follow and inspect a cable at a depth of 2,100m using the high-definition images transmitted by the Nautile.

The Nautile, Ifremer's manned submarine, diving Photo © Ifremer

1 March

Delmoges: limiting incidental catches of cetaceans

Noting an increase in dolphin bycatch in the Bay of Biscay since 2016, Ifremer, La Rochelle University, and the CNRS have launched Delmogues (Delphinus movement management) research project, which aims to gain a better understanding of the interactions between dolphins and fishing activities within the ecosystem, and to identify solutions to reduce bycatch.

Dolphins at the bow of a fishing boat Photo © La Rochelle University, CNRS, Pelagis, JJ BOUBERT

13 April

A short film to discover the French Oceanographic Fleet

Directed by Rémy Marion and Stéphane Durand, and featuring the voices of two ocean enthusiasts (Jacques Perrin et Jean-Marc Barr, this film presents the staff, resources, expeditions, and challenges of the French oceanographic fleet, one of the largest in the world. Uploaded online on 13 April 2022, the film took a year to make.

On-board camera on the ships of the French Oceanographic Fleet
Photo © Rémy Marion

2 June

Framework agreement with France Nature Environnement

Taking a further step towards strengthening links with society, Ifremer has signed a 5-year framework agreement with France Nature Environnement (FNE), which brings together nearly 9,000 nature protection associations in France and French overseas territories. The aim is to structure collaboration between Ifremer and FNE around the protection of the oceans and the responsible use of marine resources.

François Houllier, CEO of Ifremer, and Arnaud Schwartz, president of France Nature Environnement signed a framework agreement.

28 June – 27 July

École Bleu Outremer on board the *Marion Dufresne II*

Aboard the largest ship in the French oceanographic fleet, 75 students from the scientific, maritime, and artistic disciplines sailed from La Réunion to Mayotte to discover the Indian Ocean and its challenges. This month of learning and exchange culminated in a seminar organised on board with the participation of 25 elected representatives, senior government officials, scientists, and public funders.

Class photo on the deck of the Marion Dufresne for the students of the Ecole Bleu Outremer class of 2022 Photo © Ifremer/Louis Bouscary

4 July

Bluefins wins i-Lab 2022 competition

Supported by Ifremer's innovation programme, the start-up Bluefins is developing a sustainable propulsion system inspired by whale flukes. This hydrofoil won over the jury of the i-Lab competition, organised by the French Ministry of Higher Education and Research. Bluefins is one of 78 winning companies in the 2022 competition, selected from 396 applicants.

The hydrofoil designed by Bluefins being tested in Ifremer's tanks. Photo © Bluefins

27 September

"Science and Ethics" day on tribute to Axel Kahn

Through this day of reflection and sharing on science and ethics, which brought together 120 people, Ethics in Common, the joint ethics advisory committee on Inrae, CIRAD, Ifremer, and the IRD, wanted to pay tribute to the spirit of openness and dialogue of its former president, Axel Kahn, a renowned doctor and geneticist, who died on 5 July 2021.

Axel Kahn's speech at the symposium "Ensemble, protéger la biodiversité marine: connaître pour agir" ("Together, protecting marine biodiversity: knowledge for action") organised on 12 March 2020 by Ifremer and the OFB (French Biodiversity Office) Photo © Stéphane Lesbats - Ifremer

2022 Highlights

October

PhD students in the spotlight! Florence Briton and Carolane Giraud

Florence Briton, who completed her PhD at Ifremer, was awarded the *Australian Agricultural and Resource Economics Society*'s prize for the best thesis in the field of agriculture and resource economics, for her work on fisheries management, modelling and ecoviability. Carolane Giraud was awarded the 2022 Young Talents France Prize by the L'Oréal-UNESCO Foundation for Women in Science. A doctoral student at the Lagoons, Ecosystems, and Sustainable Aquaculture (LEAD) laboratory in New Caledonia, her PhD focuses on the study of environmental phenomena and microbial communities affecting shrimp farming, a key economic activity on the island.

Carolane Giraud (left), winner of the 2022 Young Talents France Prize by the L'Oréal-UNESCO Foundation for Women in Science, and Florence Briton, winner of the best thesis prize from the Australian Agricultural and Resource Economics Society Photo © Jean-Charles Caslot

19 October

Welcoming a a delegation from France 2030

At its Mediterranean centre in La Seyne, Ifremer welcomed Bruno Bonnell, General Secretary for Investment who is leading France 2030 and its Deep Seabed section. Bruno Bonnell and his delegation were shown a large number of operational underwater vehicles (AUV Ulyx, HROV Ariane, ROV Victor 6000, Nautile) and various achievements in artificial intelligence and underwater robotics.

Bruno Bonnell (4th from left) and the France 2030 Plan delegation visiting theIfremer Mediterranean centre at La Seyne (Var), 19 October 2022.
© Erick Buffier - Ifremer

20 October

Hcéres evaluation report on Ifremer

The French High Council for the Evaluation of Research and Higher Education (Hcéres) has published its report on Ifremer for period 2016-2020. Praising the scientific excellence and the quality of its research, the richness of its opening to society and the economic world, the committee of experts recommends that the Institute continue its dynamic transformation by improving certain practices (interdisciplinarity, partnership strategy, foresight, budget balance, risk analysis, skills management, etc.).

21 October

Creation of the mixed research unit Decod

Ifremer, Inrae, and the Institut Agro have inaugurated the joint research unit (UMR) "Dynamique et durabilité des écosystèmes: de la source à l'océan" [Dynamics and sustainability of ecosystems: from source to ocean"] (Decod). The research carried out by this joint multi-site unit (Brest, Lorient, Nantes, Rennes) involving 150 researchers, engineers, and technicians, aims to better anticipate the pressures caused by human activities on continental and marine aquatic biodiversity.

The UMR Decod team at its first general meeting in 2022 Photo: © Ifremer

28 October

State support for fisheries expertise

During a visit to Brest, Hervé Berville, Secretary of Sate for the Sea, and François Houllier, CEO of Ifremer, signed a framework agreement on the financial support provided by government to Ifremer for the collection and development of fisheries data and expertise. This agreement will complement the scientific studies and monitoring expeditions carried out by the Institute in this field.

Hervé Berville (left), State Secretariat for the Sea, and François Houllier, CEO of Ifremer (right) at the signing of their agreement.
Photo © Stéphane Lesbats - Ifremer

7 November

A European agreement on research evaluation

François Houllier has involved Ifremer in the European coalition for the reform of research evaluation, which is based on four major principles: recognising the diversity of scientific contributions and careers, giving priority to qualitative peer evaluation, banning the inappropriate use of metrics based of the reputation of journals, and avoiding the use of institutional rankings in the evaluation of researchers.

François Houllier, CEO of Ifremer Photo © Cyril Marcilhacy / Collectif Item

7-18 November

Participation in the Ocean Pavilion at COP 27 in Egypt

For the first time at a United Nations Conference on Climate Change (COP), the international ocean science community came together in a joint pavilion. Alongside around twenty of its international counterparts, Ifremer called for recognition of the role of the ocean in regulating the climate, and of the critical role of ocean sciences.

December

Launch of the first Ocean-Climate PRP projects

PROGRAMME PRIORITAIRE DE RECHERCHE OCÉAN & CLIMAT

Led by Ifremer and CNRS, the "Ocean and Climate" priority research programme (PRP) selected 6 projects in its first call for applications. Two of them, Climartic and Lifedeeper, are coordinated by Ifremer, which is also a partner in the following ones: Future-Obs (Sorbonne University), Mediation (Inria), Riomar (CEA), Futurisk (La Rochelle University).

50 years of engagement in the Pacific

On 4 October 2022, at its Vairao centre on the island of Tahiti, Ifremer celebrated the 50th anniversary of its establishment in the Pacific, in the presence of Polynesian authorities and representatives of the government.

The event was a reminder that, through its research and support for local socio-economical activities, the Institute is a key partner for regional authorities in the field of marine science and technology.

Above:
The Ifremer Pacific Centre was established in 1973 in Vairao Bay, 70km (43 miles) south-east of Papeete. Photo © Heivini Le Gléau (Société Kotaha)

Right page:
1- Cultured pearls produced by the *Pinctada margaritifera* oyster at the Ifremer Pacific Centre. Photo © Olivier Dugornay - Ifremer
2- Philippe Moal, Director of the Ifremer Pacific Centre. Photo © Olivier Dugornay/Ifremer - CCBY
3- Pearls oysters, *Platax orbicularis* disease, diversification of aquaculture sectors, adapting ecosystems to climate change: there is no shortage of research topics for for the staff at the Ifremer Pacific Centre. Photo © Heivini Le Gléau/Société Kotaha

Dynamic partnership with academic and economic stakeholders

Thanks to its two sites in French Polynesia and New Caledonia and the deployment potential of the French Oceanographic Fleet, Ifremer has a solid foothold in the Pacific Ocean, which has been strengthened gradually through partnerships with various stakeholders from the public and private sectors. The Institute has a long and special relationship with the Marine Resources Directorate (MRD). This Polynesian public service, under the supervision of the Minister for Culture, the Environment, Marine Resources, in charge of crafts (MCE) has a general competence in the pearl farming, fishing, and aquaculture sectors.

Ifremer is also a founding member of the "Research, Higher Education, and Innovation for Polynesia" (RESIPOL) consortium, which brings together the University of French Polynesia (UFP), the National Centre for Scientific Research (NCSR), the Louis Malardé Institute (LMI), the Institute for Development Research (IRD), École pratique des hautes études (EPHE), the University of Perpignan (UPVD), and University of California-Berkeley. This consortium has made it possible to respond to ambitious calls for proposals and to work on key issues in French Polynesia.

Numerous links have also been forged with the local socio-economic world. Ifremer has worked hard with the aquaculture industry to help them improve their daily practices, diversify, and reduce their impact on the environment. The Institute has also made its experimental platforms available to its partners and hosts newly-established Polynesian companies.

A scientific approach focused on the sustainability of the aquaculture industry

Today in French Polynesia, the research carried out at the Ifremer Pacific Centre is based on three major challenges: the diversification of aquaculture production, the adaptability of species to global changes, and the reduction of the impact of aquaculture on the environment.

The Institutes's scientists are contributing to the development of pearl oysters, shrimps, and *Platax orbicularis* fish. They are testing new species to develop aquaculture industries (oysters for consumption, fish, sea cucumbers, and sea urchins) and to promote the restoration of the coral ecosystem. They are studying the biological adaptation mechanisms brought into play by these species in the face of climate change, in order to help these industries adapt to future transformations. The scientists are also looking at the impact of aquaculture practices (plastic or chemical contamination linked to fish farming). The goal is to establish pollution indicators (to support public policy) and to develop bio-remediation approaches to limit environmental discharges from aquaculture.

A wide range of ambitions

Sustainability, responsibility and restoration are the key words that will continue to guide Ifremer's work in Polynesia. Still working closely with local stakeholders, the Institute will be taking its studies into herd health, genetic characterisation of species of interest to aquaculture, adaptability to global change, and the environmental impact of aquaculture further. A more ecosystem-based approach is also planned.

In addition to the topics covered by staff at the Tahiti site, Ifremer is also bringing the Pacific zone the many studies being carried out by its other teams on marine resources and biodiversity, marine renewable energies, the role of the ocean in the climate system, exploration of the water column, knowledge of active underwater volcanoes, etc.

The French Oceanographic Fleet around the world

Maintaining security measures linked to Covid and the rise of inflation has had a significant impact on the activities of the French Oceanographic Fleet, but the modernisation of vessels has continued as a sustained pace, with 3 major renovation projects launched. In the end, most of the test programs were able to be completed.

Significant progress in the renewal of vessels and equipment

Ulyx, the latest autonomous submarine in the French Oceanographic Fleet, diving during the Essulyx test program in 2022. Photo: Olivier Dugornay – © Ifremer

The past year has been a busy one for ship modernisation. The *Atalante* entered the shipyard in September 2021 in Concarneau, and was put back into service in February 2022 following a major refit: replacement of the generators and deep-sea winch, and heavy maintenance to guarantee continued operation until 2030. The *Antéa* and the *Côtes de la Manche* have also been modernised during this period. The first vessel has undergone extensive refurbishment, including the replacement of some of its acoustic equipment. It has also been prepared to receive a medium-depth multi-beam echo sounder, which will be installed as soon as its co-financing with the French National Research Institute for Sustainable Development (IRD) is secured. The *Antéa* joined arrived in New Caledonia at the end of 2022 to replace the *Alis*. The *Côtes de la Manche* has benefited from a complete upgrade of its scientific equipment. It is now capable of carrying out shallow water fishing expeditions.

Testing of the Ulyx autonomous submersible has also been continued. Two technical expeditions were carried out in the Mediterranean and the Atlantic on the *Pourquoi pas?* in the first half of 2022,The Hermine 2 campaign, conducted during the summer of 2022, demonstrated the capacity and potential of this innovative underwater platform, but also reveals component defects that were analysed and partly resolved by the Oceanographic Fleet Management teams in the following months. Development tests will continue in 2023, with Ulyx due to enter operational service in the first half of 2024.

Another milestone was the launch of call for bids for the construction of the Channel Atlantic Semi-Shore Vessel (CA-SSV). Due to a price increase of around 30% linked to the economic situation, the functional programme has to be adjusted to the available budget while remaining consistent with the objectives of the French Oceanographic Fleet medium-term plan (MTP). Bids received in January 2023 will be examined by Ifremer's Board of Directors in March 2023.

Ambitious campaigns despite the persistence of Covid and inflation

The manned submarine Nautile dives into the middle of the Atlantic on a maintenance mission for the EMSO-Azores seabed observatory located on the Lucky Strike hydrothermal field. Photo © Ifremer/Damien Roudeau

In order to ensure secure access to the ships and to return to a level of activity close to f previous years, the French Oceanographic Fleet has continued the practice of starting and finishing expeditions in French cities and overseas territories. Nevertheless, some cases of Covid occurred during certain expeditions. Difficulties in transporting equipment also led to a reduction in the duration of several offshore and coastal missions. The sharp rise in the cost of energy has also led to the postponement of the DIADEM offshore mission to early 2023 and the cancellation of non-priority expeditions (known as "P2") from mid-2022. These restrictions have resulted in 388 days of scientific activity by offshore vessels instead of the 448 days initially planned. However, 2022 was marked by a number of flagship scientific expeditions, of which the following are a few examples.

Focus X2 on the Pourquoi pas? Project was aimed at setting up an additional system and maintaining the temporary passive seismological network that had been installed previously. Comprising of thirty-one seabed seismometers (OBS), it uses new fibre-optic detection technology. It is dedicated to monitoring an active strike-slip fault located twenty kilometres (12.4 miles) off the coast of Catania, at the boundary between the African and Eurasian plates. The expedition also included taking sixteen sediment cores near the cable to be laid in 2020.

Also on the Pourquoi pas?, the Arc-En-Sub expedition aimed to gain a better understanding of the tectonic, magmatic, and hydrothermal processed in the Rainbow massif, a hydrothermal field in the Mid-Atlantic Ridge off the Azores. Using the Idefix and Victor 6000, the scientists explored two types of systems, one active, acidic, and high-temperature (Rainbow), and the other two fossilised (Clamstone and Ghost City). The data collected will be used to build on new models of fluid circulation and fluid-rock interaction.

The Resiste project, on the *Thalia*, focused on studying the resilience of a disused granulate extraction site, the Pilier, located off the Loire estuary. By observing the mechanisms at work over a period of several years, the scientists aim to determine the restoration capacity of an ecosystem subject to intense anthropogenic pressure.

The *Marion Dufresne* hosted the Resilience project, which combined the Cyclops and Reaction applications. Its aim was to study the links between fine oceanic scales (fronts and whirlpools) and marine life as a whole, from phytoplankton to large mammals. The mission took place between the Southern Mozambique Channel and the Agulhas Current..

The French Oceanographic Fleet, a key player in two major events

The French Oceanographic Fleet played an active part in two events that marked the year 2022: a major international conference organised in Brest on oceans, and a new type of floating school.

On 9 February 2022, the French Oceanic Fleet took park in the *Achieving Better Coordination of the European Research Fleets round-take* organised by Ifremer as part of the *One Ocean Summit*, in Brest. The aim of this event was to present a proposal for a governance and an economic model for a permanent structure to coordinate European fleets. It was the culmination of discussions held as part of Work package 8 (coordinated by the Italian CNR and Ifremer) of the Eurofleets+ project. The Star Research Infrastructure (*RI) is therefore continuing its work to become part of the European landscapes.

From 28 June to 22 July, the French Oceanographic Fleet also hosted a first-of-its-kind expeditionon board the *Marion Dufresne*, the École Bleu Outremer. The initiative consisted of welcoming seventy-five students (in science, social sciences, art and communication, or future sailors) to experience an oceanographic expedition from the inside, alongside researchers and an experienced crew, in the south-west Indian Ocean. The project, which was developed by Ifremer and the French Ministry for Overseas France, was born from the ambition to share an expedition with young people from different backgrounds (mainland France, overseas France, countries in the Indian Ocean region) to bring them together and raise their awareness of the richness and importance of the oceans.

A practical course at the Ecole Bleu Outremer, with students on board watching the deployment of a bathysonde to acquire phisico-chemical data on the Indian Ocean
Photo © Ifremer/Louis Bouscary - CCBY

Protecting and restoring the seas and the ocean

A living, healthy, safe, and resilient ocean

By seeking to understand the marine environment, monitoring it, and analysing the risks, Ifremer is helping to preserve out common future for a living, healthy, safe, and resilient ocean.

The rich biodiversity of the ocean floor

Based on environmental genomic analysis of samples collected from different parts of the global ocean, a group of scientists have shown that the biodiversity of sediments on the ocean floor is at least three times greater than that of the water column.

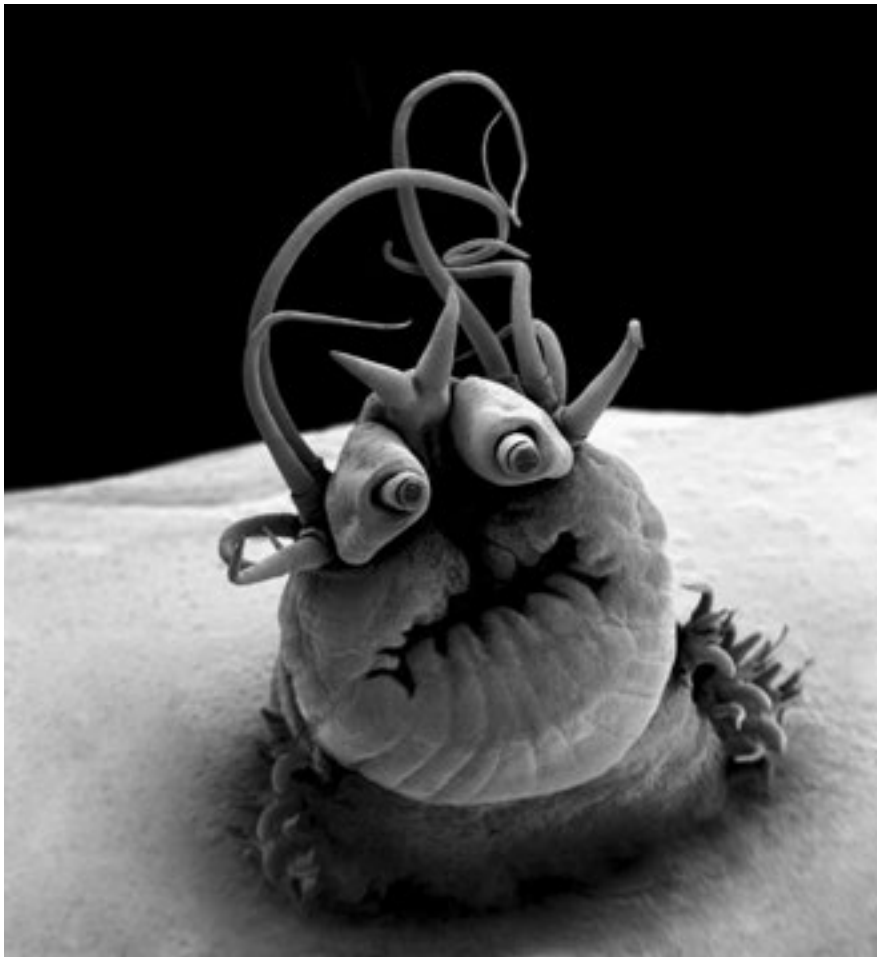
The ecosystems of deep sediments are among the least explored biological environments on the planet, despite being the largest (50% of the Earth's surface), they are difficult to access and require heavy equipment at sea to be studied. They provide habitats for diverse communities that support fundamental ecological processes and services, such as nutrient recycling and carbon sequestration on a geological scale.

For almost 50 years, considerable effort has been made to study these environments, but it has tended to focus on the morphological analysis of macro- and mega-fauna, neglecting the study of microbial and meiofaunal organisms (smaller than 1mm). Thanks to the recent development of high-speed genomic evaluation methods and technologies, these gaps are beginning to be filled. Environmental DNA, obtained from samples taken in the studied environment and not directly from an organism, is gradually providing valuable information.

As part of an international collaborative project (Norway, Switzerland, France, United Kingdom, Germany, Spain, and United States) involving scientists from Ifremer, the richness of deep sediment ecosystems has been highlighted. Comparing molecular inventories from samples taken at different locations and depths in the global ocean, the study showed that the sedimentary seabed offers much greater biodiversity than the water column. It also revealed previously unknown species and made it possible to distinguish between indigenous organisms and those that flow through the water column, shedding light on the circulation and sequestration of organic carbon from the upper ocean.

These results come from two Merlin projects, "Pourquoi Pas les Abysses" and France Génomique -eDNAbyss.

Cordier Tristan, Angeles Inès Barrenechea, Henry Nicolas, Lejzerowicz Franck, Berney Cédric, Morard Raphaël, Brandt Angelika, Cambon-Bonavita Marie-Anne, Guidi Lionel, Lombard Fabien, Arbizu Pedro Martinez, Massana Ramon, Orejas Covadonga, Poulain Julie, Smith Craig R., Wincker Patrick, Arnaud-Haond Sophie, Gooday Andrew J., de Vargas Colomban, Pawlowski Jan, "Patterns of eukaryotic diversity from the surface to the deep-ocean sediment", *Science Advances*, 2022. https://archimer.ifremer.fr/doc/00750/86191



An abyssal sediment dweller: this polychaete worm from the Nereididae family, recognisable by the tuft of cilia at the top of its head, lives near hydrothermal springs. © Gilles Martin

An operational assessment framework to assess the vulnerability of marine ecosystems

At a time when governments are pledging to create protected areas covering at least 30% of their land and sea territories, an international research team is working to better characterise and quantify the vulnerability of marine biodiversity in order to rationalise ecosystem management and conservation policies.

While attention is currently focused on the climate emergency, there are many other threats to biodiversity. Pollutions, invasive species, disease, and the overexploitation of resources are pressing threats whose cumulative impact on ecosystems is difficult to assess. The complexity of biological responses to this wide range of threats and the current ambitions to preserve biodiversity mean that we need to broaden the usual approach, which is too often divided, to consider the functioning of ecosystems as a whole.

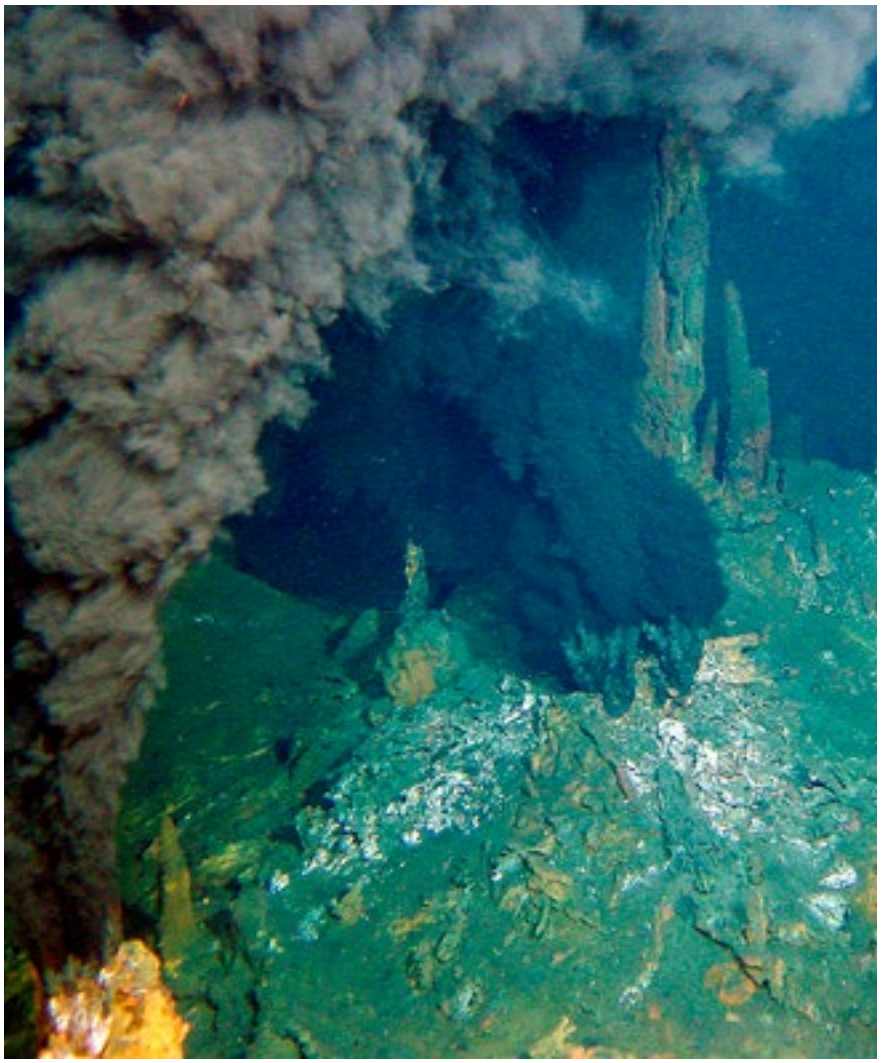
A team of around twenty scientists from the IRD and international organisations has been working on this as park of two projects funded by the Foundation for Research on Biodiversity (FRB), with the support of Électricité de France (EDF) and France Filière Pêche (FFP).

At the heart of this new method for assessing vulnerability in the idea of the functional diversity of communities. By looking at the role played by each species in the functioning of the ecosystem, the distribution of these functional traits in the community (abundance, redundancy, rarity) and the reaction of species to different disturbances, it becomes possible to measure the vulnerability of an ecosystem in a more standardised operational and rational way. Successfully tested, notably in the North Sea, this framework is a promising tool for simulating the evolution of certain communities under the pressure of multiple disturbances, and for identifying the most fragile sites. It can therefore guide the efforts of decision-makers to protect biodiversity.

Arnaud Auber, Conor Waldock, Anthony Maire, Eric Goberville, Camille Albouy, Adam C. Algar, Matthew McLean, Anik Brind'Amour, Alison L. Green, Mark Tupper, Laurent Vigliola, Kristin Kaschner, Kathleen Kesner-Reyes, Maria Beger, Jerry Tjiputra, Aurèle Toussaint, Cyrille Violle, Nicolas Mouquet, Wilfried Thuiller, David Mouillot, "A functional vulnerability framework for biodiversity conservation", *Nature Communications*, 2022. https://doi.org/10.1038/s41467-022-32331-y/

Beautiful but fragile... Faced with these threats, researchers are calculating the vulnerability of marine ecosystems in order to protect them more effectively. Here: an eelgrass meadow in Finistère. © Olivier Dugornay/Ifremer - CCBY

The underestimated role of the deep ocean in carbon sequestration



Surprising hydrothermal vents: not only are they an oasis of life, they also play a little-known role in carbon sequestration.
© Ifremer - C/O Momar 2008 - CCBY

Recent studies of hydrothermal vents and abyssal sediments have revealed that the deep ocean's high biodiversity enables the capture of more CO_2 than scientists had previously thought.

It is now estimated that the ocean absorbs 25% of the CO_2 emissions caused by human activities, making it a major 'carbon pump' and an essential climate regulator. However, relatively little is known about the deep ocean's contribution to this process, which made recent discoveries about the biodiversity of the deep sea all the more interesting.

One of these studies relates to the hydrothermal vents that line the thousands of kilometres of mid-ocean ridges, and more specifically the high-temperature gas column that escape from them. A team from Ifremer has shown that these plumes produce twice as much biomass as is generally observed at these depths, making them an oasis of life and a carbon reservoir that is largely underestimated in previous studies. The micro-organisms living in these vents transform around 3% of the total organic carbon dissolved in the water into what is known as particulate carbon. This can then be recycled by other micro-organisms within the vent or sink to the bottom of the ocean where it is trapped.

These results, published in Nature Communications, combined with those showing the rich biodiversity of abyssal sediments, demonstrate the role of the deep ocean in carbon assimilation and could help improve climate models such as those used by the IPCC (Intergovernmental Panel on Climate Change).

Cathalot, C., Roussel, E.G., Perhirin, A. *et al,"* Hydrothermal plumes as hotspots for deep-ocean heterotrophic microbial biomass production*", Nature Communications* 12, 2021

Contrasting development of honeycomb worm reefs under the effect of climate change

Extending from Morocco to Scotland, honeycomb worm reefs could move northwards in Europe as the climate warms, while breaking up and disappearing in the areas that are the most heavily populated.

Honeycomb worms are small sedentary marine worms living in a tube of sandy sediment that they build by producing their own glue. When agglomerated, these tubes form reefs that can extend over several square kilometres and play an ecological role (shelter for many other species, protection of the coastline against erosion). Found along foreshores from Morocco to Scotland, they are particularly fond of the French Atlantic coast.

As part of the Reehab (Reef habitat) project, a team from Ifremer has studied their probable evolution by 2050, assuming a 2 °C in temperature. The results show that honeycomb worm colonies would increase in size (+27.5%) under the effect of such a rise in temperature, extending their distribution area to the north of Scotland and into the eastern channel. On the other hand, scientists have observed that the distribution areas currently favoured by this species, such as the Charente Channel and Vendée, could become broken, making movement between reefs increasingly difficult and eventually leading to their gradual disappearance from these areas.

The REEf HABitat project is led by Ifremer and funded by the French Office for Biodiversity. It involves three foreign scientific partners: the University of Porto (Portugal), Bangor University (Wales), and the University of Plymouth (England). The results will be used to prioritise areas of importance for the species in Europe, and could therefore guide and help policies for defining marine protected areas. Find out more: **www.hermelles.fr** (in french) / **honeycombworms.org** (en anglais) https://onlinelibrary.wiley.com/doi/10.1111/gcb.16496

Above: Close-up- portrait of a honeycomb worm head topped with its crown of silks.
© Stanislas Dubois - Ifremer

Bottom: No rocks on this beach, but agglomerated honeycomb worm reefs. These tiny 3cm marine worms can build colonies up to two metres high.
© Stanislas Dubois - Ifremer

The role of submarine deltas and canyons in the burial of organic carbon on geological time scales

At the Géo-Océan joint research unit, sedimentologist Sophie Hage is deciphering the carbon cycle in the sediments of submarine canyons.
© Olivier Dugornay - Ifremer

Sedimentologist Sophie Hage is interested in particulate organic carbon transported from the continents to the seabeds. She joined the Geo-Ocean laboratory (University of Brest and Ifremer) as a post-doctoral fellow in the European MSCA-Bienvenüe* programme. In 2022, she contributed to the publication of three studies, published in *Nature Geoscience* and *Nature Communications*, she carried out on the underwater canyon of the Congo River and on a 70-million-year-old delta in Patagonia.

What carbon sequestration processes are you working on, and why this particular interest in underwater deltas?

The carbon cycle regulates life and the climate on Earth, involving the atmosphere, the terrestrial and marine biospheres, and the lithosphere. Personally, I'm interested in the organic carbon carried by rivers into oceans and then stored in the sediments on the seabed. This mechanism is important because it can lead to CO_2 reductions in the atmosphere over geological time. Submarine deltas and canyons are fundamental to this process as they form the link between the continents and the seabeds, constituting megacentres of continental carbon sequestration.

Why did you go to Patagonia to study this ancient emerging delta?

The sediment cores taken from the current seabed don't allow us to go back very far in time, and we wanted to find out how this carbon storage evolved over millions of years. So we went in search of very old deltas whose surface were caused by tectonic movements and erosion. My colleagues at the University of Calgary had identified a unique site in Patagonia, a perfectly preserved delta from the Late Cretaceous (70 million years ago), with geological deposits exposed over hundreds of kilometres. We stayed for five weeks and dug a 525m trench to expose the delta deposits, describing them every 10cm and taking rock samples every 5m. We also used a drone to make a 3D model of the delta. Back in Calgary, the samples were analysed to determine the levels of buried carbon and to identify the origin of this carbon (continental or marine). We found that the carbon buried in the delta was of continental origin, with sequestration rates close to those observed in today's deltas, confirming that deltas played a major role in the long carbon cycle.

What avenues are you currently exploring at Ifremer through your study at the Congo River submarine canyon?

I'm trying to understand how organic carbon is transferred from the continents to the present-day seabed in order to gain a better understanding of the short and long carbon cycle. To do this, I am combining coring data conventionally used in sedimentology with oceanographic measurements (Doppler current meters, particle traps).

My current study site is the Congo. This river ends its course in an estuary that opens out into an estuary that open out into a long (>1000km) underwater canyon which large quantities of organic carbon are carried. I am currently working on data collected during an offshore survey carried out by Durham University (UK) in 2019, in which Ifremer was a partner. A new study is scheduled for 2024, during which Ifremer is due to deploy an AUV (underwater robot) to carry out precise mapping of the canyon floor.

What are the main findings of these three studies?

They help quantify the contribution of submarine systems to land-sea particle transfers and the carbon cycle, which plays a major role in regulating our climate. Compared to other, much faster mechanisms such as plant photosynthesis, the quantities of carbon trapped annually in marine sediments may seem small (a ratio of 1 to 1000). However, the study of the ancient delta in Patagonia has confirmed that carbon storage is effective over particularly long-time scales. This provides food for thought about the various natural services provided by the ocean in terms of carbon sequestration and their time scale.

* The Marie Skłodowska-Curie Actions (MSCA) fund excellent research and innovation and equip researchers at all stages of their career with new knowledge and skills, through mobility across borders and exposure to different sectors and disciplines.

Brittany's "BIENVENÜE" programme is one of the Marie Curie initiatives, providing financial support for 75 post-doctoral students to work in Breton laboratories.

Hage Sophie, Romans Brian, Peploe Thomas, Poyatos-Moré Miquel, Haeri Ardakani Omid, Bell Daniel, Englert Rebecca, Kaempfe-Droguett Sebastian, Nesbit Paul, Sherstan Georgia, Synnott Dane, Hubbard Stephen, "High rates of organic carbon burial in submarine deltas maintained on geological timescales" *Nature Geoscience*, 2022.
https://doi.org/10.1038/s41561-022-01048-4

Pope E.L., Heijnen M.S., Talling P.J., Silva Jacinto R., Gaillot A., Baker M.L., Hage S., Hasenhündl M., Heerema C.J., McGhee C., Ruffel S.C., Simmons S.M., et al., "Landslide-dams affect sediment and carbon fluxes in deep-sea submarine canyons", *Nature Geoscience*, 2022.
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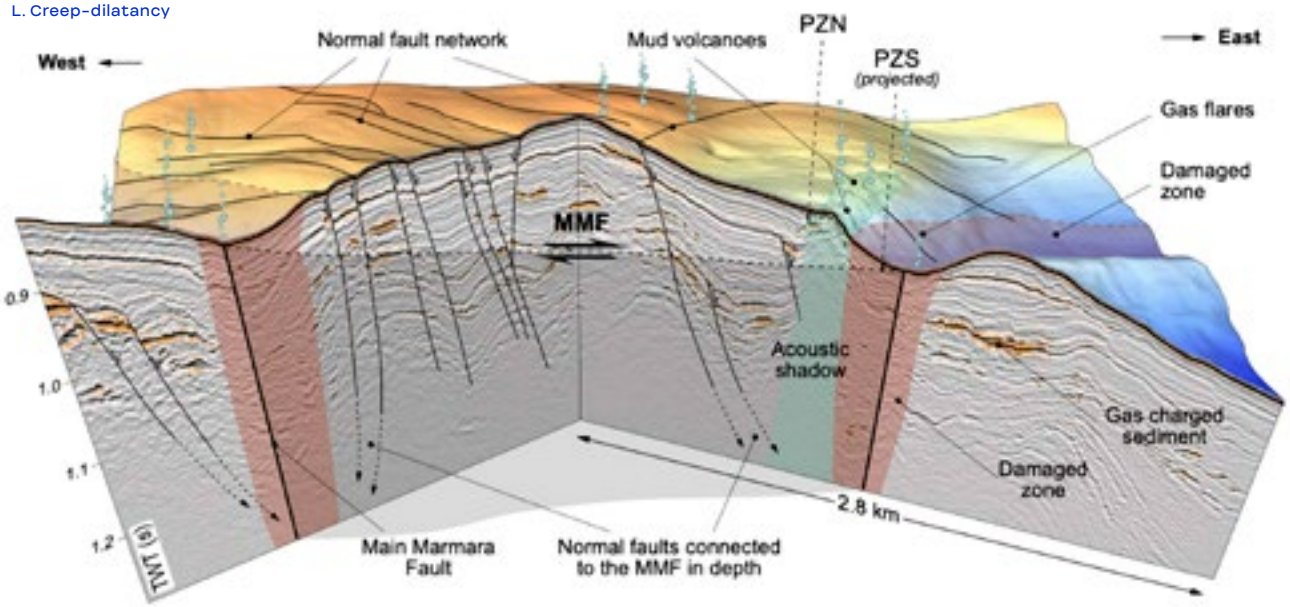
https://doi.org/10.1038/s41467-022-31689-3

Accelerated research into slow, low-magnitude earthquakes



3D map of the fault zone beneath the Marmara Sea. © N., Murphy, S., Riboulot, V. & Géli, L. Creep-dilatancy

Thanks to an in-depth study of water pressure in marine sediments, Ifremer scientists are providing major insights into the phenomena of slow, low-magnitude earthquakes and their role in triggering larger tremors in certain regions of the world.

As the earthquake along the East Anatolian fault on 6 February 2023 reminded us, Turkey is located in a region of the world subject to significant seismic activity. During 2022, Ifremer conducted studies on another fault in the region, which runs beneath the Sea of Marmara, less than 50 kilometres (31 miles) from the city of Istanbul.

This fault has also been the source of several destructive earthquakes in the past, such as the Izmit earthquake in 1999 (magnitude 7.2 to 7.6).
In this zone, particular phenomena known as slow, low-magnitude earthquakes or SSE (Slow Slop Event) occur on the tectonic boundary between Anatolia and Europe. To explain the origin and identify the consequences of these episodic slow landslides, Ifremer researchers deployed piezometers in the region to measure the water pressure in marine sediments and used land-based GPS stations to detect and measure tectonic deformations.

Published in Natural Communications, the study revealed a correlation between the fluctuation in pressure in the underwater sediments and the deformations observed on land during a 10-month slow slip event. The piezometer could therefore become an interesting tool for measuring and monitoring seismic activity. By analysing these slow deformations over a relatively long period, the study has also provided valuable information on the functioning of the North Anatolian fault, showing in particular that its progression poses very serious seismic risks for the megalopolis of Istanbul.

Find the article on *Nature Communications*
https://www.nature.com/articles/s41467-022-29558-0

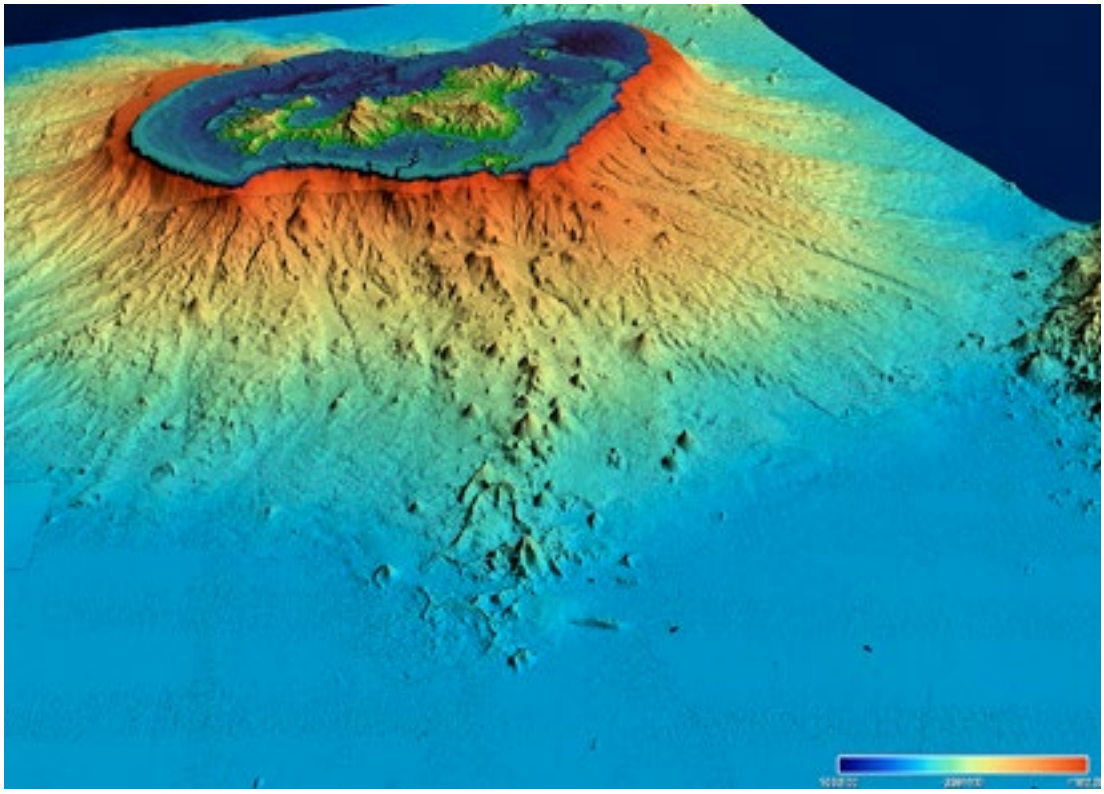
Launch of the Marmor project to increase geophysical monitoring of the seabed

Aimed at better structuring and equipping the French scientific community in seismology and underwater geodesy, Marmor will implement a seabed observatory for the study and monitoring of volcanism in Mayotte.

The Equipex+ Marmor (*Marine Advanced geophysical Research equipment and Mayotte multidisciplinary Observatory for research and Response*) project will provide the French scientific community with mobile equipment to advance the study of earth deformation, seismicity, tsunamis, volcanism, and several key environmental mechanisms on the oceanic and coastal domains. The project brings together 11 institutions and 3 national research facilities: the French Seismological and Geodetic Network (Resif), the European Network of Submarine and Water Column Observatories (Esmo) and the Coastal Research Infrastructure (Illico).

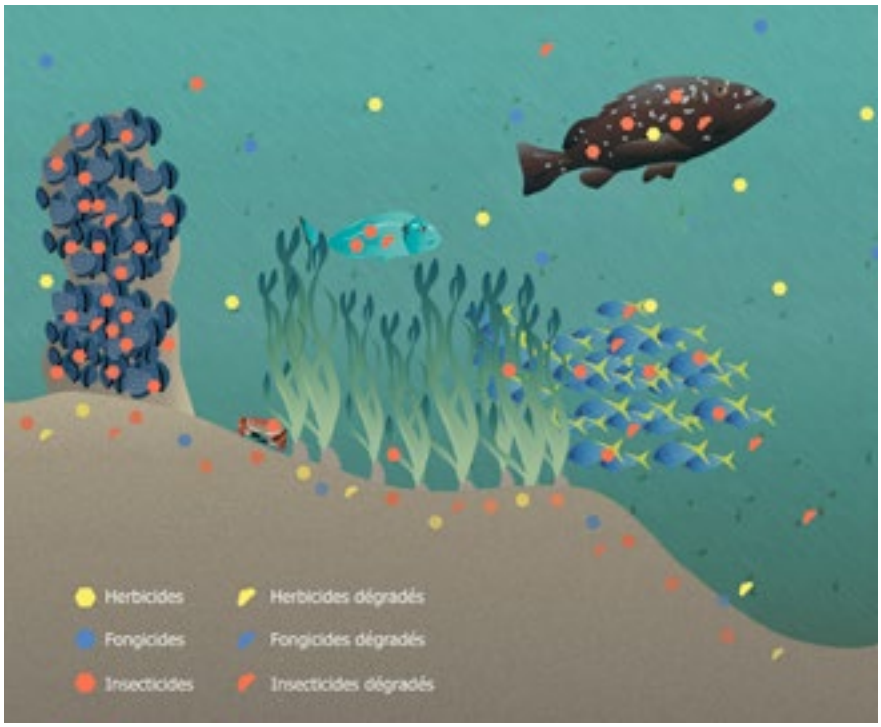
A part of Marmor, a multidisciplinary observatory of the seabed and water column will be built and installed on the outskirts of Mayotte to monitor and analyse the underwater seismic-volcanic crisis that has been underway since May 2018. This observatory will complement Mayotte's volcanological and seismological monitoring network (Revosima) and will be used for research in a variety of areas: interactions between tectonic and volcanic processes, changes in deep-sea ecosystems in response to volcanic forcing, research into the emergence of life and biological colonisation processes in a volcanic context etc. From a scientific point of view, thanks to innovative equipment, it will contribute to the understanding of telluric hazards. From a technological point of view, it will complement the developments carried out as part of Ifremer's exceptional scientific investment programme (PIE ScInObs).

The project has received €15.4m in government funding over 8 years. It is managed by the Agence Nationale de la Recherche (French National Research Agency) as part of the Investissements d'avenir (Future Investments) programme under France 2030, under the reference ANR-21-ESRE-002.



View of the underwater volcano responsible for the seismo-volcanic crisis that Mayotte has been experiencing since 2018. © Ipgp-Brgm-Ifremer-Cnrs

An up-to-date knowledge overview of the impact of plan protection products



The presence of pesticides or PPPs (plant protection products) has been documented in the marine environment, including in remote areas such as the poles and the deep seabed. © Lucile Wargniez

Led by Ifremer and Inrae*, the collective analysis of a large body of scientific publications worldwide confirms the impact of plant protection products on biodiversity and ecosystem services on land and at sea.

For two years, 46 experts from 19 different organisations studied more than 4,000 scientific publications worldwide to draw up an inventory of the contamination of environments and living organisms by plant protection products. Commissioned by the French Ministries of Ecological Transition, Agriculture, and Research, this study represents an essential update of the previous reports (2005 and 2008), as these products have changes considerably over the last 15 years. Still used on a massive scale to protect crops and green spaces against 'pests', these substances have become more prevalent, their cross-fertilisation giving rise to a 'cocktail' effect that is complex to understand.

However, thanks to improved sampling, analysis and detection capabilities, we now have a more accurate picture of the situation.

The analyse shows a high level of contamination of the ecosystems in which these products are applied, but also their presence in very remote environments, such as areas close to the poles and the deep seabed, demonstrating that they are widely distributed from land to sea. Exposure to plant protection products has also been proven for a wide range of organisms, confirming the spread of these substances along the food chain (invertebrates, birds, etc.). Some studies identify acute direct effects, even leading to the deaths of individual plants, while others note indirect impacts (reduction in food resources, elimination of habitats, impact on pollination). These products clearly act as an aggravating factor in the state of health of terrestrial and marine ecosystems. This report also looked at the subject of biocontrol (the use of natural organisms and substances), but there is still a lack of scientific work on their impact. It also sheds light on regulatory monitoring and assessment methods, the available means of limiting the impact of plant protection products and the need for further studies.

* Inrae (Institut national de recherche pour l'agriculture, l'alimentation et l'environnement).

Sophie Leenhardt, Laure Mamy, Stéphane Pesce, Wilfried Sanchez, Impacts des produits phytopharmaceutiques sur la biodiversité et les services écosystémiques [Impact of Plant Protection Products on Biodiversity and Ecosystem Services], ESCo Summary Report, Inrae-Ifremer, 2022.

Ecological monitoring of seawater near nuclear power stations

Michel Ropert is in charge at Ifremer of ecological and fisheries monitoring in the areas surrounding France's five seaside power stations.
© Benjamin Simon - Ifremer

Michel Ropert, a member of the Normandy Environmental and Resources Laboratory, has been in charge of ecological and fisheries monitoring in the surrounding areas of nuclear power plants (CNPE) since 2016. Ifremer has been carrying out this work for EDF for almost 40 years as part of the Impact des grands aménagements (Impact of major developments, IGA).

What's the history of this IGA project which goes back to Ifremer's earliest days?

In the 1970s, when the French government launched the plan to build nuclear power stations, some fifteen potential coastal sites were identified. In the end, five were selected and gradually developed: four on the Channel/North Sea coast (Gravelines, Flamanville, Penly, Paluel) and one in the Gironde estuary (Blayais). As these centres use seawater for cooling, EDF is required by law, as the operator, to organise monitoring of discharges and any impact them may have on the marine environment.

The ecological aspect of this monitoring was assigned to two national organisations dedicated to understanding the ocean (CNECO) and the scientific monitoring of fishing (ISTPM), which merged in 1984 to form Ifremer. Our Institute has continued this monitoring mission for EDF under multi-year contracts that have been renewed to this day. This is a restructuring project that has led to the recruitment of hundreds of people. More than a hundred people are still employed today to carry out this surveillance.

What exactly does this monitoring involve and how has it evolved?

The initial strategy has not changed fundamentally, although it has been adapted to changes in the regulatory requirements for each site. The aim is still to observe the marine environments surrounding the nuclear power plants, and to keep an eye on how they are changing. We have several measuring points: upstream of the water intakes, in the zone of influence of the discharge structures, and outside this zone to have a reference point.

Observations are made in three areas: the water column (physico-chemical parameters, plankton, microbiology), the seabed (macro fauna, macro algae), and fishery resources (crustaceans and fish). We take measurements and samples at predetermined frequencies. These are generally seasonal, but can also be monthly, as in the case of the Blayais power station in Gironde, where we work with the University of Bordeaux.

What reports do you have to provide EDF, and what does this ecological monitoring tell us?

For each of the five sites, we have to provide annual monitoring reports presenting our observations and an analysis of data. We are particularly interested in thermal and chemical influences, but not radioactivity, which is outside Ifremer's field of expertise. Generally speaking, on all the sites we have observed over 40 years, we can say that the thermal influence of power stations spreads very quickly (over 100m) and that there are no perceptible effects in relation to other global factors such as global warming.

Between 2016 and 2018, we reconstructed and put all the historical monitoring data into the Quadridge database, opening up new possibilities for use beyond the initial monitoring mission.

Are there any other partnerships with EDF, particularly concerning the scientific exploration of these 40 years of data?

We are working with EDF, the owner of the monitoring data, on the scientific use of this extraordinary data. For example, we took part in the discussion organised by their Thermal-Hydrobiology group, which is looking at the effect of thermal discharges into the sea in relation to climate change. The aim of this initiative was to identify new avenues of research, and two Ifremer theses were finally selected, one of which will be based on data from the monitoring. These theses are part of a partnership agreement. Other discussions are underway with EDF Renouvelables They concern subjects such as environmental DNA or the assessment of resilience thresholds in relation to marine renewable energies.

Sustainable management of marine resources for the well-being of human societies and the health of marine ecosystems

An ocean of solutions

Ifremer conducts research, innovated and conducts expert assessments to propose sustainable solutions to feed, treat, or produce energy and materials for the soon-to-be 9 billion human beings on earth, while preserving marine biodiversity and protecting ecosystems.

State of fish populations in Europe in 2022

Carried out by Ifremer in partnership with three other institutes, the report was presented to the press shows that while overfishing is declining in Europe, the situation remains uneven from region to region. The European aim of 100% sustainably caught fish has not yet been achieved.

Ifremer, in collaboration with the Agro Institute's Fisheries, Sea and Coastal Unit, the Flemish Research Institute for Agriculture, Fisheries and Food (Ilvo), and the Irish research organisation Marine Institute, has drawn up a 2022 inventory of fish populations fished in Europe. A summary was presented at a press conference, covered by around forty journalists and viewed online by several thousand Europeans. This overview, covering the Mediterranean to the Baltic, confirms the general trend observed for almost 20 years, i.e a reduction in the number of overexploited populations and an overall increase in the biomass of the species surveyed. On the Atlantic coast, only 28% of the populations assessed were overexploited in 2020, compared with 80% in the mid-2000s. This represents significant progress, but it is not enough if we consider that the European Union was aiming at that time and in that area for fishing to come entirely from sustainably caught populations.

There are still a number of tensions in the North Sea and the Baltic Sea, but it is above all in the Mediterranean that fishing pressure remains high and fish abundance low. In addition, the impact of climate change is clearly visible on fish: their distribution changes, their diet decreased and their growth slowed.

Modelling tools are becoming increasingly accurate, leading to worrying projections of a significant decline in marine animal populations. Faced with the challenges that these developments represent for the management and preservation of resources, the Institute's scientists are fully mobilised in the search for solutions.

Access the balance sheet at: https://www.ifremer.fr/fr/comment-vont-les-poissons-en-europe

Operation to sort fish species as part of the Obsmer programme to observe catches at sea
© Olivier Dugornay - Ifremer

ObsMer celebrates 20 years with a French Tour

ObsMer is a system to observe-catches at sea. It plays an active role in assessing fish populations and fishing activity, and celebrated its 20th anniversary by meeting fishermen and highlighting all its contributors.

As a complement to scientific fishing operations and the analysis of data of fish auctions, ObsMer is an essential tool for observing catches at sea as a whole, i.e taking into account both the fish landed and those thrown back into the sea by fishing vessels. Under the supervision, of the Directorate-General for Maritime Affairs, Fisheries, and Aquaculture, this collaborative programme brings together scientists from the Institute, who provide project management assistance, consultancies employing observers and volunteer fishermen who take observers on board. In 2022, 410 vessels took on board 50 observers, who sampled 4,000 tonnes of fish and measured almost 400,000 individual fish.

To mark ObsMer's 20th anniversary, Ifremer wanted to thank all those involved and raise awareness of the scheme within the industry. Photos and video interviews have been produced to highlight the collaboration between fishermen and observers. Available via the Ifremer website and social networks, they were also showcased at four special events organised in Sables-d'Olonne, Boulogne-sur-Mer, Guilvinec and Sète.

These informal meetings, open to fishermen, observers, industry representatives, and project partners, provided an opportunity to get to know each other and discuss the ObsMer programme.

Video testimonials: https://www.youtube.com/results?search_query=obsmer

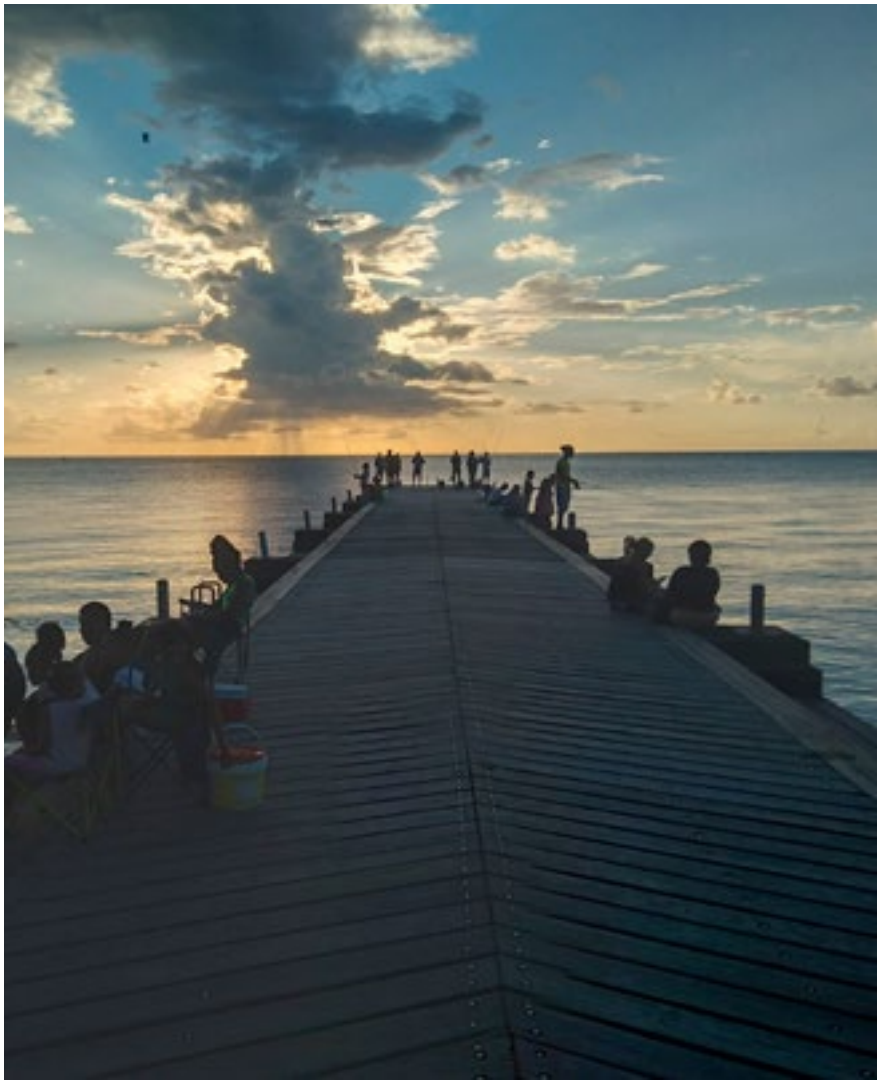
Recreational fishing in the Antilles analysed by Recreafish

Launched in 2020 to gain a better understanding of recreational sea fishing practices in the Antilles, the RecreaFish project has published is final results, which show the economic importance of this leisure activity and its significant impact on fish stocks.

Co-financed by the French Office for Biodiversity and Ifremer, the RecreaFish project was initiated by Ifremer to supplement the patchy data available in the French Antilles (Guadeloupe, Martinique, Saint-Barthélemy, and Saint-Martin). A survey was carried out to find out more about the number of people who fish and their profiles, and to gather economic information about this activity. In the first stage, almost 100,000 telephone contacts were made to obtain a study panel of 3,500 households across the four islands. Volunteers were then given a 'fishing log' and asked to record information about their fishing trips and catches. A final report was drawn up and the results of the study were presented at the *Gulf and Caribbean Fisheries Institute's* annual conference, held in Fort Walton Beach in the United States from 6 to 11 November 2022.

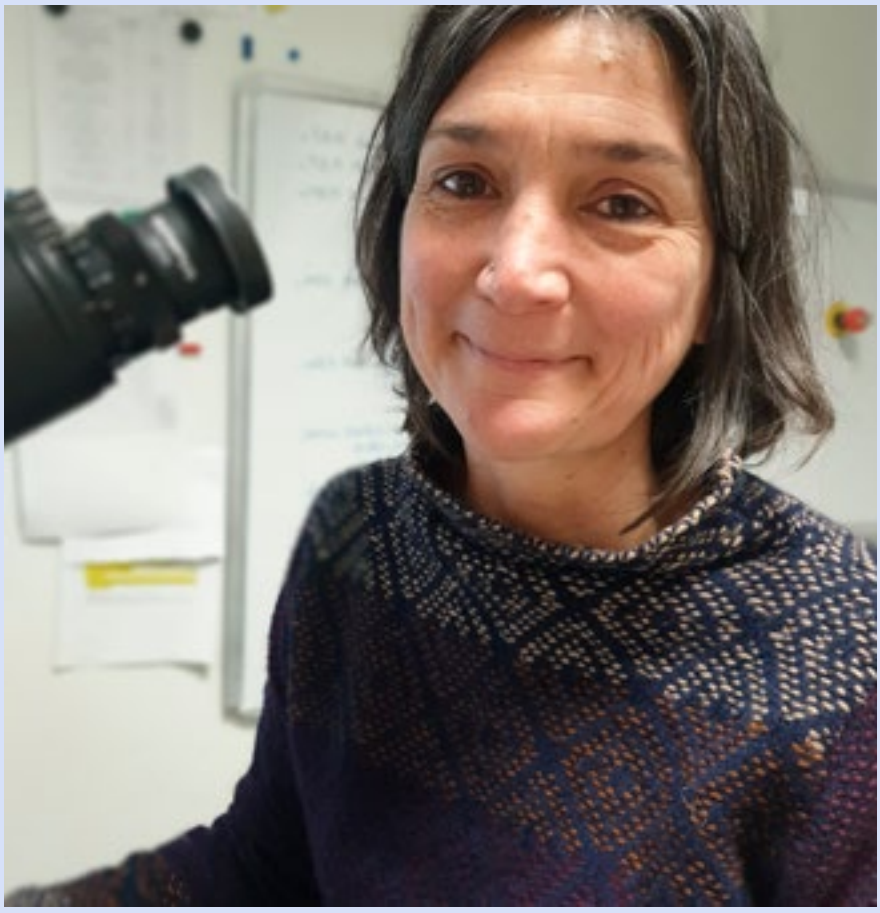
Analysis of the data confirmed the importance of recreational fishing, both in terms of the economic spin-offs it generates and the amount of fish taken from the resource. These clearly need to be taken into count as part of the ecosystem-based and sustainable fisheries management of the Antilles. This information will soon be used to improve the initial assessments of fishery resources. The study will also contribute to the national debate on the implementation of a relevant data collection system in the overseas territories,

Access the RecreaFish final report
https://archimer.ifremer.fr/doc/00804/91574/



Fishing is a popular pastime in the French West Indies, as a study confirmed by an Ifremer study of 3,500 households.
© Jérôme Baudrier - Ifremer

Publication of a biosafety and disease management manual for marine molluscs



Isabelle Arzul, coordinator of the European Vivaldi project, has worked on the publication of a best practice guide for the management of marine mollusc diseases.
© Faustine Verger - Ifremer

Isabelle Arzul, member of Ifremer's Adaptation and Health of Marine Vertebrates unit, coordinated the Vivaldi project, in which 21 European partners have developed tools and strategies to better prevent and mitigate the impact of diseased in bivalve molluscs.

What is the background of your work on mollusc diseases?

There has been an increase in the frequency of deaths of bivalve molluscs associated with diseases. This affects both farmed populations, which are of economic interest, and wild populations, which are of ecological interest. Both generally occupy the same coastal area and can be affected by diseases caused by viruses, bacteria, or parasites. Our aim is to gain a better understanding of how these diseases appear, how they develop, and, ultimately, how we can limit their emergence and spread.

Our priority is to target the diseases with have the greatest impact and with which we are most familiar. For example, we are looking at the OsHV-1 virus, which is associated with significant deaths in young hollow oysters. We are also working on the *Vibrio aestuarianus* bacterium, which affects older individuals, and on the protozoan parasites *Bonamia ostreae* and *Marteilia refringens*, which greatly reduced populations of flat oysters in the 1960s and 1970s, an endemic European species that is the subject of restoration projects.

What does the Vivaldi project involve?

It brings a European approach to these issues. This is essential, because there are a lot of transfers of bivalves between France, Ireland, Portugal, the Netherlands and so on. For example, young oysters produced in France are exported to other countries to grow and may return to France at the end of their rearing cycle. It was to take this aspect into account that we proposed the European Vivaldi project.

From 2016-2020, it brought together 21 European partners and gave many scientists, producers, and relevant authorities to discuss and work on these issues. I coordinated this programme on behalf of Ifremer. We obtained interesting and varied results on the pathogenic organisms themselves, the way in which they are dispersed in the environment, how shellfish are able or unable to defend themselves, and the interactions with environmental factors.

So this disease management manual was the final step in the project?

In a way. It's one of the last 'products' to be produced. We have published out scientific results extensively, but we wanted to go further and propose practical recommendations. With a few scientific colleagues who were particularly sensitive to the concepts of management and biosafety, we invited producers and the relevant authorities (on transfer and control issues) to join us in drawing up this manual.

This joint development, which was not very common at the time, was a real strength. It enabled us to cross the sometimes very different points of view, between categories of stakeholders and between countries including Spain, France, Ireland, and Italy. We really became aware of the differences that existed from one country to another in terms of the application of regulations, the organisation of sectors, and cultures. We worked together with great enthusiasm to identify the key issues and prioritise the recommendations.

What are the main recommendations?

Some are fairly general. We emphasised the need for better communication between scientists, producers, and regulators at a European level to circulate knowledge and best practice on risk management. Others concern governance, to improve monitoring and international coordination during crisis phases. And, of course, there are technical recommendations on water treatment, animal selection, and farming practices.

Has distribution of the guide started?

Yes. In 2022. We called in a professional to ensure a high-quality layout and we translated the original English document into French and Spanish to make it easier to read. The various participants in the Vivaldi project have distributed it to their network of scientists, producers, and relevant authorities. An electronic version is readily available and we continue to distribute the printed version to interested parties.

Find the manual:
https://www.vivaldi-project.eu/fr/Activites2/VIVALDI-Manual-for-disease-management-and-biosecurity

An environmentally-friendly alternative to antibiotics to protect hollow oysters from bacterial infections?

Phages versus bacteria: a future remedy developed at Ifremer against infectious diseases in hollow oysters (and without antibiotics!). © Stéphane Pouvreau - Ifremer

An Ifremer team is studying the key mechanisms that could make it possible to use certain viruses and phages against certain bacteria responsible for high mortality rates in hollow oysters.

The World Health Organisation considers antibiotic resistance to be one of the most serious threats to global health and food safety. More and more bacteria are adapting by developing defence mechanisms that render ineffective the medicinal solutions previously used. At the same time, it is proving more difficult to produce new, effective molecules to renew our panel of antibiotics. Finding eco-responsible alternatives, particularly to protect livestock, is therefore becoming a key objective.

In the framework of an advanced ERC[1] (*A mechanistic approach to understand microbiome-viriome dynamics in nature*), Ifremer researcher Frédérique Le Roux and her team set out to study phages in the marine environment, predatory viruses that attack certain bacteria while leaving other organisms unharmed.

They found that phages associated with pathogenic bacteria of the Vibrio genus on hollow oysters were capable of blocking bacterial defences by recovering certain genes, unlike antibiotics. The results were published in 2022 in *Nature Microbiology*.

Ifremer scientists are now continuing their research into this interesting ability of phages in the hope of developing more effective and sustainable treatments for infectious diseases in hollow oysters.

1. The European Advanced Grants Scheme (maximum value €2.5 millions) is aimed at established researchers wishing to develop an innovative exploratory research topic.
Piel D., Bruto M., Labreuche Y. et al., «Phage-host coevolution in natural populations», *Nature Microbiology* 7, 2022. https://www.nature.com/articles/s41564-022-01157-1

Diffusion of nanoplastics in fish organisms

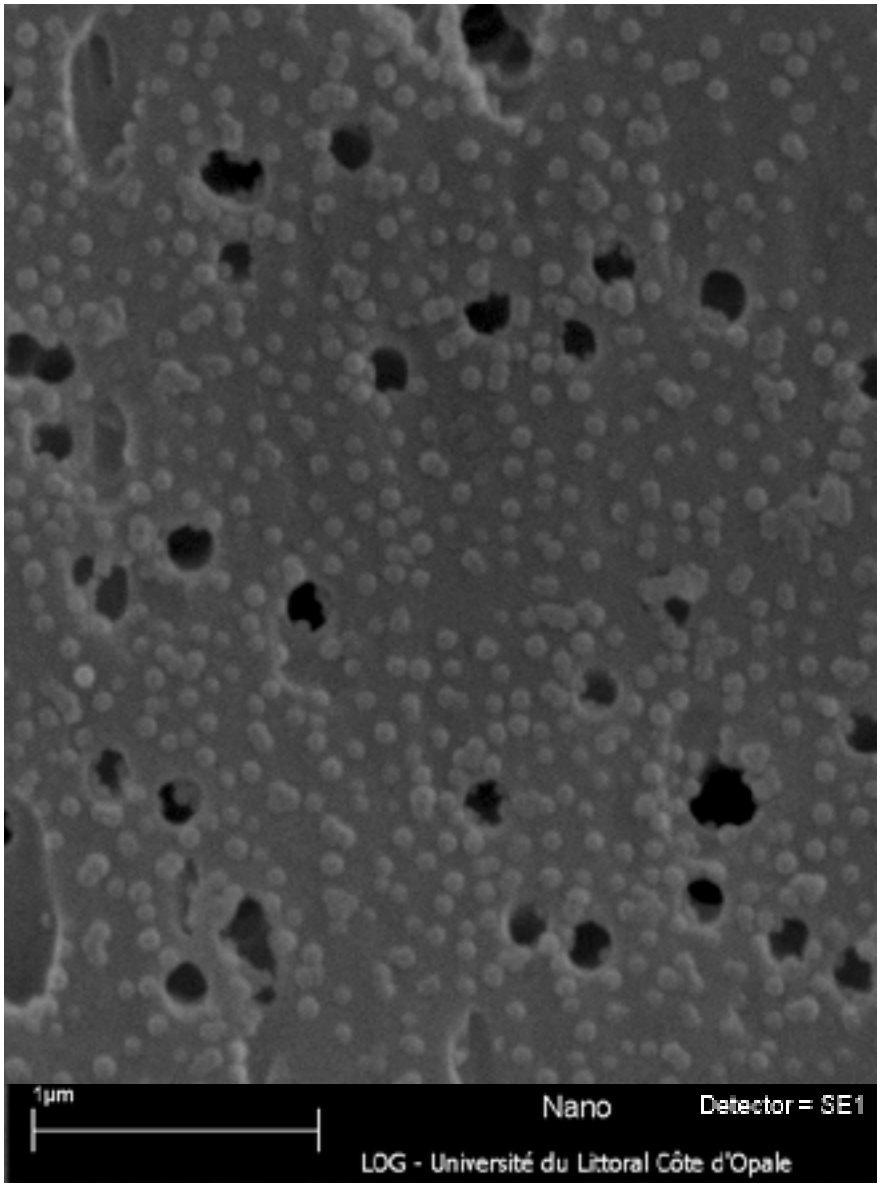
Scientists at Ifremer have experimentally demonstrated that plastic particles pass through the intestinal walls of fish and can therefore enter the bloodstream and reach the organs.

Plastic pollution is now a well-identified problem that worries the authorities and has recently led to a number of regulatory changes (such as banning single-use plastics in the European Union). For scientists, faced with the widespread presence of plastic in marine ecosystems, many questions remain, particularly about the digestion of nano (smaller than a thousandth of a millimetre) and microplastics by living organisms, one of the main controversial issues is whether these particles, which are released through the food chain, enter the bloodstream and reach the organs of the fish by crossing the intestinal barrier.

Published by the *Environment International* journal, the experimental study conducted by Ifremer, provides some answers by demonstrating the passage of polystyrene nanoparticles through the intestinal epithelium of European sea bass. Based on an *ex vivo* approach, which involves sampling and mounting a fish intestine in an experimental device, this study involves three additional techniques: fluorescence measurement, visual inspection by scanning electron microscopy, and chemical analysis by high-resolution mass spectrometry (Py-GC-HMRS).

This combination has enabled us to dispel any remaining doubts about this intestinal transfer and to propose a mechanism to explain the appearance of plastic particles in the internal organ of fish via the bloodstream.

Vagner, M.; Boudry, G.; Courcot, L.; Vincent, D.; Dehaut, A.; Duflos, G.; Huvet, A.; Tallec, K.; Zambonino-Infante, J. -l. "Experimental Evidence That Polystyrene Nanoplastics Cross the Intestinal Barrier of European Sea bass", *Environment International*, 2022. https://doi.org/10.1016/j.envint.2022.107340



The evidence is in than nanoparticles (shown here microscopically) are able to enter the bloodstream and organs of the fish; This is worrying news, highlighted in a study by Ifremer. © Lucie Courcot/ ULCO (Université du Littoral-Côte d'Opale)

Not-so-inactive seabed sulphide clusters

The Hermine 2 project revealed that ancient hydrothermal springs considered "extinct" still generate sufficient activity to sustain microbial life and remnants of biodiversity.

The contract to explore the polymetallic sulphide mounds of the Mid-Atlantic Ridge, awarded by the International Seabed Authority (IBA), was operated on behalf of France. Sometimes rich in metals such as iron, copper, or zinc, these clusters are priority targets for companies planning to extract undersea mineral resources. The first Hermine project in 2017 led to the identification of six new hydrothermal fields. Carried out from 9 July to 24 August 2022, thanks to France 2030 funding for the deep seabed, the second project continued with this exploratory work, particularly focussing on hydrothermal systems considered to be 'inactive' or 'extinct'.

Aboard the *Pourquoi pas?*, the Hermine 2 team, visited the Trans-Atlantic Geotraverse (TAG) site, a hydrothermal field at a depth of around 3,645m that has been studied for over 40 years. The exploration of clusters considered to be extinct was carried out with the Nautile deep-sea manned submarine and the new Ulyx autonomous robot, which was involved in a scientific expedition for the first time.

The observations showed that hydrothermal activity persisted in certain clusters, generating fluids at temperatures of between 3.2°C and 30°C, high enough to allow bacterial colonies to develop and certain species to survive.

This discovery has led scientists to reconsider extinct sulphide deposits. The notion of inactivity needs to be re-examined in the light of a more detailed understanding of the geological, chemical, biological, and microbiological processes at these sites and their spatial and temporal expansion.

Funding:
France 2030

An extinct hydrothermal source does not necessarily mean the absence of life, as demonstrated by this colony of bacteria thriving at 3645m below sea level at the TAFG site in the Mid-Atlantic Range.

Deep Seabeds PRPE (Priority Research Programs and Equipment)

Jean-Marc Daniel, Director of the Physical Resources and Seabed Ecosystems Department and leader of the Deep Seabed PRPE project and Ifremer.

Director of the Physical Resources and Ecosystems of the Seabed Department, Jean-Marc Daniel is leading Ifremer's development program dedicated to the deep seabed, a subject at the crossroads of multiple issues.

What is the background of this PRPE and what are its goals?

As part of the France 2030 plan, the French government has launched a number of initiatives to speed up exploration of the deep seabed, and this PPER (Priority Research Programs and Equipment) is part of that effort. The deep sea raises a number of ecological, industrial, geostrategic, diplomatic, and legislative issues. We still lack the knowledge to deal with them rationally.

There is an area where fundamental geological phenomena are taking place, which is home to very rich ecosystems and significant mineral resources, and which also hosts strategic installations for the transport of energy and information. Through the PRPE, the French government aims to boost scientific research on the deep seabed.

On which specific themes does it focus?

As with all research projects, the main objective is of course to produce new knowledge, but we wanted to take a very inclusive approach to this project so as to truly be multidisciplinary and bring a new perspective to the subject. We are therefore taking a broad approach to the deep seabed, from the ocean floor to the entire water column, looking at these areas as places where energy and matter are exchanged, and as habitats for marine organisms. The aim is to assess the state and understand the dynamics of the deep sea and associated ecosystems, as well as their role in the planet's equilibrium, particularly in terms of biodiversity and climate.

We also want to examine the way our societies perceive these areas. Shared by the general public, the researchers themselves and the decision-makers, they influence the measures taken within the framework of the law and international agreements. They also affect scientific, artistic, and commercial practices. We will therefore be looking at the physical, biogeochemical, and biological processes at work in the deep sea, while inviting representatives from other disciplines to contribute to the debate (such as the law of the sea, maritime economics, industrial risks, etc.).

How many partners are involved?

The scientific program will be led by the CNRS, Ifremer, and the IRD. However, alongside the traditional scientific council, we want to set up a stakeholder committee. Here too, our aim is to be inclusive, to involve various representatives of society in the discussions, starting with the stakeholders from the overseas territories who are directly affected by these issues. We also hope to include NGOs and businesses. The advantage of the PRPE is that it offers visibility over a relatively long period of time (9 years). We also plan to coordinate as soon as possible with other initiatives launched as part of the France 2030 plan in order to make the best use of the resources available.

What stage has the project reached?

The application was submitted to the Ministry of Higher Education and Research and for the General Secretariat for Investment in December 2022. We hope to have feedback on its assessment very soon.

The «InOcean» innovation process

Using predictive maintenance to reduce the cost of offshore wind farms, stimulating the immune system of hollow oysters against a virus, or using what fins as inspiration for low-carbon ship propulsion – these are just three examples of the innovative approaches rolled out in 2022.

Project development is a multi-stage process that involves transforming an idea into a product or service for the socio-economic world. At Ifremer, this innovation process, known as InOcean, is based on three additional mechanisms. Beforehand, the InO'idées challenge finances and support the pre-development of internal projects in order to test their potential. Then, by the decision of the InOcean's steering committee, the most promising projects are taking forward to the development stage, where support is provided to demonstrate their operational potential and to patent the related innovative processes. In addition, the Octo'pousse competition encourages the creation of start-ups capable of providing sustainable solutions for the development of the blue economy.

Among the various projects whose development Ifremer, some made significant progress in 2022. Longus (an underwater system for measuring the lengthening of textile mooring lines), which came out of the InO'idées 2020 programme, is now entering the patent application phase and the search for industrial partners. This sensor system, which can be used for predictive maintenance, has been very well received in the world of marine energy, as it reduces the costs associated with anchoring the platforms supporting offshore wind turbines.

Similarly, the start-up Bluefins, after an impressive development process, now has 6 employees and has enters into a partnership with TotalEnergies. Its wave powered system, inspired by whale fins, can reduce the energy consumption of shits by 20%. Finally, the Star project, for "Stimulation antivirale chez l'huître *Crassostrea gigas*" ("Antiviral stimulation in the *Crassostrea gigas* oyster"), which proposes a method for protecting young oysters from episodes of large-scale deaths due to OsHV-1 herpes virus.

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A swarm of underwater micro-drones wins the Octo'pousse competition

For its second annual innovation competition, Ifremer has chosen the DEESS project, which aims to implement a swarm of drones capable of taking high-resolution photographs of the seabed over large areas.

Today, images are playing an increasingly important role in the study of the seabed, and various types of equipment are used to acquire them. However, the existing underwater vehicles and robots, which are generally equipped with a range of high-performance instrumentation, are expensive and difficult to operate.

Frédéric Mittaine, leader of the DEESS project, is considering additional solutions for acquiring detailed data at lower cost, without the need for divers or specialised vessels.

The idea is to deploy around a hundred simply-designed micro-UAVs a few metres from the seabed and at four-metre intervals. Coordinated by surface drones, they will be able to take high-resolution photographs of more than one square kilometre per hour. Thanks to high-performance image processing, these photos can be combined and used for mapping applications (photogrammetry) or to help monitor ecosystems and identify ecosystems and identify points of interest.

Ifremer will be working with the Nice-based start-up to develop the data acquisition system, the image processing, and the enhancement chain. For 18 months, Yannick Pennençot, an engineer on the DEESS project, will be recruited at the Ifremer centre in La Seyne-sur-Mer to benefit from the expertise of the teams there in the field of underwater vehicles.

Contribution to the national strategy “Advanced technologies for energy systems”

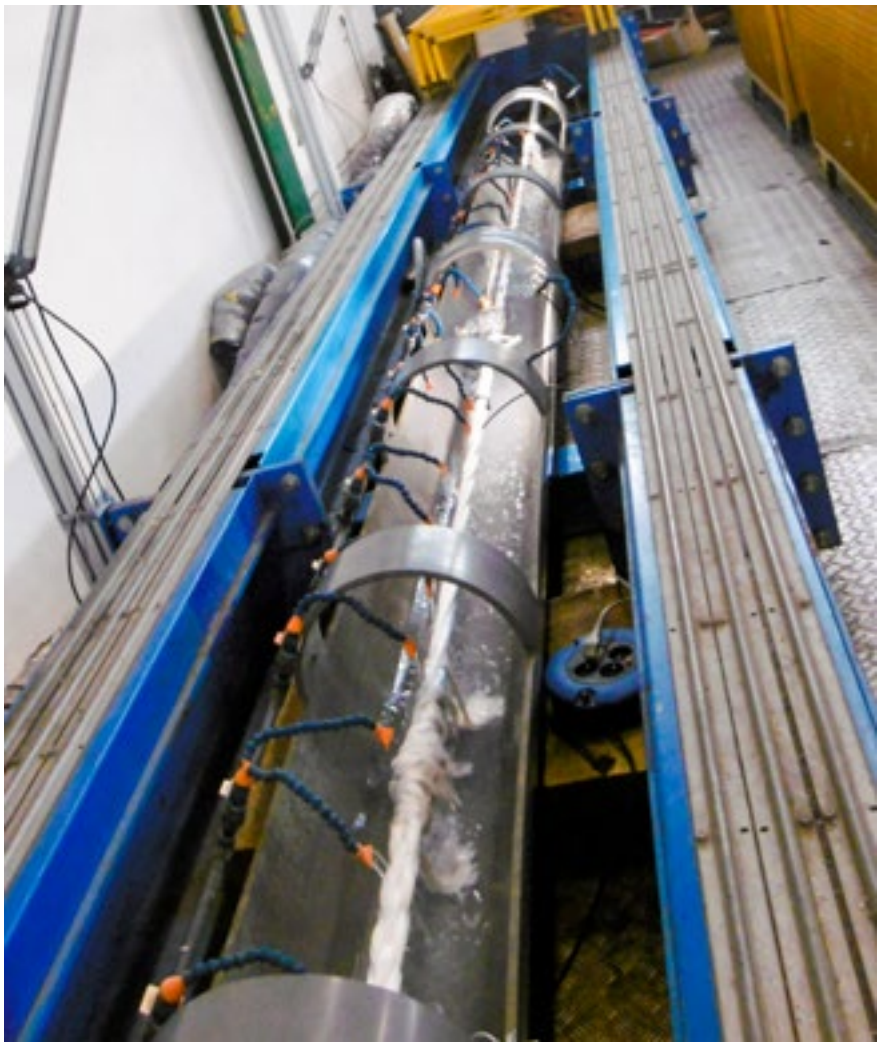
Ifremer is involved in two development projects for floating wind turbines as part of a consortium of industrial and academic researchers.

As part of the France 2030 programme, the national “Advanced technologies for energy systems” (Ates) strategy aims to encourage the development of a French industry in the new energy technologies by targeting three priority sectors: photovoltaic, floating wind power, and energy networks. In response to a call for projects issued by the French Environment and Energy Management Agency (Demo-Tase), Ifremer has been selected to take part in two projects led by BW-Ideol and Eolink.

The HT20MW Eolink operation aims to deploy a high-voltage mechanical and electrical connection hub that will be submerged at a depth of 30m and should operate maintenance-free for ten years. This equipment is primarily intended for docking floating wind turbines (an application for 20 MW machines is planned) and for exporting electricity to land. It could also be used to anchor ships at sea. Eolink has a number of partners (Everaxis Industries, France Énergies Marines, Ifremer, Gustave Eiffel University, Windgalz). Ifremer’s contribution will focus on modelling anchor lines and analysing their lifespan.

France 2030 is supporting Ifremer’s work on the Eolink 20 MW and Vellela2 projects (modelling anchor lines and analysing their lifespan, innovative anchoring solutions, and traction and fatigue testing, monitoring the FLOATGEN floating wind turbine on the marine environment, habitats, and seabed communities.

The Vellala2 Ideol project is based on the Floatgen floating wind turbine demonstrator, which has been operating at the École centrale de Nantes (ECN) since 2018. The aim of the project is to reduce the environmental impact and the investment and operating costs of this system without calling its reliability into question. Ifremer will be looking, in particular, at the behaviour and durability of the alternative materials (traction and fatigue tests on cables weighing up to 100 tonnes) proposed for the anchor lines (synthetic chain links, innovative fibres etc.) and the environmental impact of Floatgen on the marine environment, habitats, and seabed communities. The project consortium also includes several stakeholders (Ideol, IVM, Ifremer, ENSTA, Brittany, Ecole centrale de Nantes).



Wind turbine ropes on the test bench in the Ifremer laboratories
© Peter Davies - Ifremer

The Blue Ocean fund raises €170m for start-ups dedicated to regenerating the ocean

Jérôme Delmas, general manager of SWEN Capital Partners. © Swen CP

Co-founder and Managing Director of SWEN Capital Partners, an investment company specialized in sustainable and positive-impact non-listed investments[1], Jérôme Delmas is delighted with the partnership built with Ifremer as part of the SWEN Blue Ocean fund.

What distinguishes SWEN Capital Partners from other investment companies?

At SWEN, environmental, social, and corporate governance (ESG) criteria play a central role in the direction of our investments, in order to have a positive impact on the world. Ten of the company's 100 employees are dedicated exclusively to this extra-financial analysis. We use tools such as the NEC (Net Environmental Contribution) indicator to measure the environmental impact of economic activities over the entire life cycle of assets. We also have one of the largest extra-financial databases in Europe. For us, people are a fundamental value. We have a dynamic, highly committed team, just like what we do. That's why our relationship with Ifremer has gone so well.

What exactly is Blue Ocean and how would you sum it up?

The SWEN Blue Ocean strategy aims to protect and regenerate the ocean and respond to three major challenges: overfishing, marine pollution, and climate change. At the time of the launch, our ambition was to raise €120 million, and by the end of the campaign we succeeded in raising €170 million, making it the largest fund for Ocean-Tech start-ups. These funds, which come from financial and institutional stakeholders, have so far been invested in nine new start-ups. So it's clearly a success.

I'm extremely proud of this project, which is outstanding example of public-private partnership. It's based on a successful partnership between the Blue Ocean team, which specialises in the Blue Economy, Ifremer, as a high-level scientific advisor, and the SWEN platform, which is both robust thanks to its mutualist shareholding (Ofi Invest, Crédit Mutuel Arkéa) and an expert in sustainable investment.

I'd like to particularly highlight the partnership with Ifremer, a first in France, because it has given the fund a great deal of credibility. The Institute invested €5 million in Blue Ocean and is also a member of the Impact Governance Committee, which annually validates the key indicators and impact targets for each investment. It can also play a supporting role in the investment process, providing scientific strategic evaluation and due diligence. For this last point, the Blue Ocean team is not obliged to call Ifremer, but we've been happy to do so since the fund was launched, at really constructive monthly meetings. Given the complexity of these ocean issues, Ifremer has provided unique added value in the choice of relevant criteria and the scientific and technological assessment of the applications. I'm firmly convinced that we need to develop this type of partnership that combines science and finance. It's the key to achieving the positive systemic impact we're looking for, to giving approach credibility with institutional investors and insuring long-term viability.

Could you describe some of the companies backed by Blue Ocean?

One of the first investments was Spinergie (France), a company that assesses and optimises the performance of the ships to limit their environmental footprint. This is an area of direct interest to Ifremer for the French oceanographic fleet it operates. We have also invested in Nature Metrics (UK), which is working on a new method for analysing environmental DNA, a technology for studying biodiversity from water or sediment samples. There could be opportunities for Nature Metrics to contribute to Ifremer's work. Noray Seafoods (Spain-Norway) is another good example of the type of positive-impact activity we want to support. This company produces shrimp in a closed circuit inland from the sea, using water recycling processes that save resources and prevent pollutants from being discharges into the sea. Its location in Europe also offers an interesting alternative to imports from Asia or South America, thereby limiting the sea transport. Ifremer's technical expertise was essential in carrying out a preliminary assessment of this investment.

Are you planning a Blue Ocean 2?

Yes, it's planned for 2024 with the aim of raising more funds. There's so much to be done in the ocean field with such a strong positive impact.

1. An unlisted company issues shares that cannot be bought or sold on the stock market. Unlisted shares are generally issued by small and medium-sized companies seeking financing directly from investors (Source: Autorité des Marchés Financiers - AMF).

Innovafeed: a sustainable alternative for feeding farmed shrimp

Data from the FAO (2022) shows that almost 14 million tonnes of fish meal from fisheries were used to feed fish and shellfish from aquaculture, which produced 68.7 million tonnes in 2020.

With this in mind, and with a view to improving the sustainability of aquaculture, the innovation department put a team of Ifremer researchers from the LEAD NC (Unité de recherche Lagons écosystèmes et aquaculture durable – Ifremer Nouvelle Calédonia (Lagoons ecosystem and sustainable aquaculture research team – Ifremer New Caledonia)) working on shrimp farming in touch with Innovafeed, a biotechnology company specialising in insect farming for animal and plant feed. This company offers *Hermetia illucens* meal, better known as the Black Soldier Fly (BSF). In addition to the fact that BSF meal could largely replace the fish meal used in shrimp feed, its production meets sustainability objectives, in particular zero waste and a circular chain. The various meetings made it possible to bring together the expectations of the company and those of the researchers, and led to the proposal of a Master 2 course from January to June 2022 on the subject of "Incorporation of *Hermetia illucens* insect meal in the diet of blue shrimp *Litopenaeus stylirostis*: a study of digestibility and influence on health". Researchers from LEMAR (Laboratoire des sciences de l'environnement marin (Laboratory of Marine Environment and Science)) and PHYTNESS (Unité écoPHYsiologie et Traits d'histoire de vie des orgaNismeES marinS (Ecophysiology and life-history traits of marine organisms team)) in Brest were associated with project for their expertise in the nutrition and physiology of aquatic animals. The aims of the internship were to assess the energy content of the feedstuffs containing the insect meal, the in vivo digestibility of BSF meal in blue shrimp, the zootechnical benefits according to different rates of incorporation of BSF meal, and finally, changes in bioindicators of digestive, immune and oxidative status in the presence of insect meal in shrimp feed. The initial data shows that it would be feasible to substitute around 40% of fish meal with BSF meal in shrimp feed.

These results prompted Innovafeed to continue its collaboration with Ifremer as part of the CIFRE thesis due to start in 2023. The study will not only refine the results on the nutritional value of BSF meal compared with fish meal, but also to determine its effects on the health, physiology, and microbiota of the blue shrimp *L. stylirosis*, in particular its protective effect against vibriosis.

The results obtained should make it possible to formulate feeds with a smaller environmental footprint, adapted to the juvenile and sub-adult phases of shrimp farming, while maintaining farm performance.

With the aim of combating overfishing, aquaculture could replace fish meal with meal from insects such as Hemetia illucents or Black Soldier Fly (BSF) to feed fish farms.

Building and sharing a digital ocean

An ocean of data and services

As in all fields, the digital transition is at the heart of marine activities, as well as our professional practices. Managing the growing amount of data and transforming it into services for citizens, businesses and the scientific community is now essential for sharing knowledge about the aquatic world, and for promoting economic growth that is respectful to the marine environment. This amount of available data is also the basis for modelling, enabling us to test hypotheses, go back into the past or project the future.

A larger and modernized experimental platform in La Tremblade

Christophe Stavrakakis, head of the EMMA (Expérimentation Mollusques Marins Atlantique (Atlantic Marine Mollusc Experiment)), who manages the la Tremblade and Bouin platforms.

Working closely with the local heads of La Tremblade (Charente-Maritime, Marennes-Oléron basin) and Bouin (Vendée, Bourgneuf bay), Christophe Stavrakakis coordinates, leads, and manages the Atlantic Marine Mollusc Experiment (EMMA).

What are the respective specialities of these two platforms?

Both are heavily involved in supplying scientists with batches of molluscs for research purposes These batches are mainly used to study diseases that affect farms or to assess the effect of chemical contamination, for example from pesticides. Scientists use these experimental facilities in particular to identify and produce animals that are more resistant to disease. They have secure areas to expose them to pathogenic micro-organisms.

The two platforms complement each other. The La Tremblade facility is equipped to work at the larval stage, while the Bouin facility is ideal for growing animals, due to the presence of underground salt water that is naturally rich in nutrients and enables the production of large quantities of forage microalgae. The experimental facilities follow this allocation of roles, with some research requiring larvae while others need larger specimens, or both.

Do you also have your own research and development activities?

Yes, with the engineers and technicians from the two facilities, we are working to improve breeding techniques and animal health safety. We are also involved in issues relating to water quality and treatment. These are essential aspects for us, as we have two objectives for protection: to treat the water entering the facilities to protect the farms from the biological and chemical pollution present in coastal waters, and to protect the environment by treating sewage. Our work in this area enables us to stay at the forefront, consolidate our expertise, and offer Ifremer ways of optimising its facilities.

What exactly does the renovation programme at La Tramblade consist of?

There has been a major extension to the surface area and production facilities. The number of rooms available in the experimental pathology area has tripled and we can now produce up to 140 experimental batches of mollusc larvae simultaneously, which is very useful for work related to being studied. Numerous technical improvements have been made. Each room is supplied with useful gases (air and/or CO_2 in particular) and water at three different temperatures (hot, warm, and cold). A fourth, warmer seawater network is used in the larval rearing rooms in order to accommodate a wider variety of experiments. The sanitary facilities have also been updated. By reorganising the spaces, we have applied the well-known principle of “moving forward” to further reduce the risks of contamination. What’s more, we have obtained zoosanitary approval, which confirms our rigour and the performance of our facilities.

Do you only welcome Ifremer staff or other scientists from academia or industry?

At the moment, we mainly meet Ifremer’s needs, but opening up our facilities to other public or private stakeholders is one of our development objectives. We have joined the European AquaExcel 3.0 network, which was originally dedicated to fish farming but now has been extended to shellfish farming. We were able to see that facilities like those at La Tremblade and Bouin are rare in Europe. We have already welcomed a technician from a Danish experimental facility, and we are currently receiving requests form researchers via this European network, as well as from the University of La Rochelle, which is interested in our experimental facilities because of the proximity of the facility.

Key figures from the La Tremblade experimental station:

- **€2.5 million** worth of renovation work, including **€380,000** funded by the Nouvelle-Aquitaine Region, and €820,000 by the European Regional Development Fund (ERDF);
- **1500 m²** of breeding and experimental facilities;
- 3 experimental parks on the foreshore;
- Seawater pumping at 50 m³/h for experimental farms.

Gaïa Data, bringing together and harmonising environmental data

The Equipex Gaïa Data aims to improve our understanding of the Earth system by integrating multi-disciplinary and multisource environmental data, currently managed in silos, into a common system.

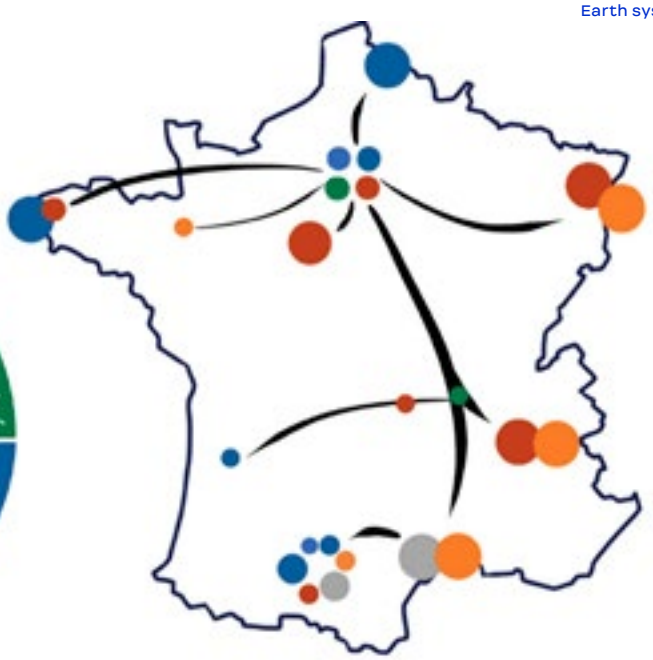
The growing and mass production of digital data is giving rise to new management and accessibility issues. France's general policy of "open data for open science" recommends implementing the FAIR (Easy to Find, Accessible, Interoperable, Reusable) principles. The Equipex (équipement d'excellence) Gaïa Data is part of this approach. Funded by the 3rd Future Investment Programme – France 2030, the project is supported by three research organisations specialising in data management (Data Terra, Climeri-France, Pôle national de données de biodiversité) and includes 21 scientific and institutional partners, themselves producers and managers and managers of data, including Ifremer.

The aim of Gaïa Data is to develop and implement a distributed platform integrating data, access services, new analysis, and processing capabilities. This will involve a number of technical hurdles linked to the volume and diversity of the data to be processed. Harmonising this highly diverse environmental data, in terms of the variety of ways in which it is acquired, the disciplinary approaches adopted and the environmental processes addressed, is a real challenge. Gaïa Data will also have to cope with the diversity of IT infrastructures operated by each of the players involved, and ensure that algorithms are shared.

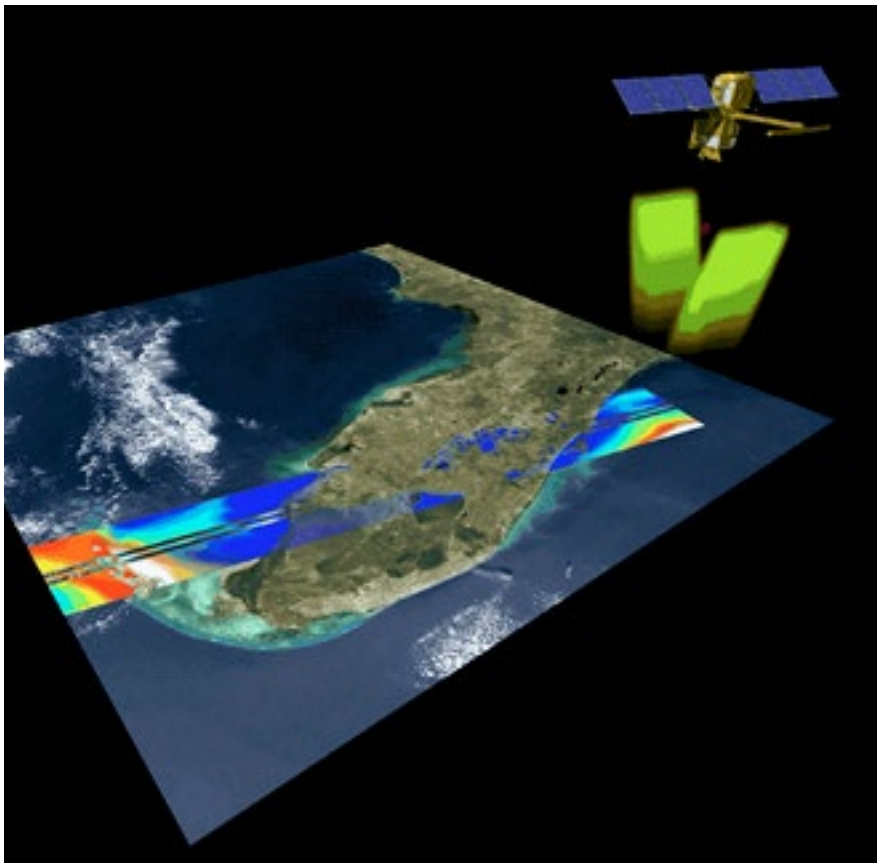
In collaboration with the existing infrastructures (national centres, regional centres, specialist centres such as Datarmor at Ifremer), and in line with the "Infranum" policy of the Ministry of Research and Higher Education, the Gaïa Data project is contributing to the evolution of the IT infrastructure model, by bringing together high-performance computing and "big data".

The funds allocated by France 2030 to the Equipex Gaïa Data are dedicated to setting up virtual research environments that complement the functionalities of Datarmor, the supercomputer at Ifremer's Computing and Data Centre for the Sea. This support is in addition to that provided by the CPER (Contrat Plan Etat-Région) Bretagne Aida, Ifremer's major investment plan and the financial contributions.

The Gaïa Data project aims to concentrate all the services and data relating to the observation, modelling, and understanding the Earth system on a single platform.



Launch of the SWOT satellite, the “watchdog of the waters”



The SWOT satellite enables scientists to keep a sharper eye on variations in sea level with an accuracy greater than current levels.
© NASA/JPL CalTech

Several Ifremer scientists took part in the international SWOT expedition, co-sponsored by Cnes and NASA, which led to the launch into orbit of cutting-edge equipment for observing the planet’s surface waters.

With climate change underway, global water monitoring is a major concern. Space hydrology has long contributed to this monitoring, but it has been faced with certain technological limits that the launch of the SWOT satellite has just overcome. Equipped with sensors with 10 times the resolution of its predecessors, SWOT can analyse small-scale surfaces in much greater detail, gathering unprecedented data. The new on-board radar, called KaRIn, offers even greater possibilities in terms of spacial altimetry.

Scientist swill be able to measure ocean levels more accurately by detecting much smaller structures formed at the surface by whirlwinds or ocean current veins. This information will help us to understand how these structures evolve and contribute to the ocean’s climatic balance by transporting masses of water and participating in the exchange of heat, carbon, and nutrients between the surface layers and those deeper down.

As a member of the SWOT scientific team, Ifremer has been involved in the development of KarIn for over ten years, seeking the best solutions in terms of orbital inclination, sampling frequency, and signal processing. Following the successful launch of the satellite on 15 December 2022, it now needs to be calibrated. To reach this stage, Ifremer and Show will jointly carry out the C-SWOT oceanographic expedition in spring 2023 on board the *Atalante* and *Téthys* vessels. These *in situ* measurements are essential to validate those taken from space by KaRIn.

Fish Intel and Popstar, two fish electronic monitoring programs

Marine Gonse worked on the deployment of an acoustic telemetry network to unravel the mysteries of 5 target species at part of the European *Fish Intel* project. © Stéphane Lesbats - Ifremer

Biologist Tristan Rouyer tracks tuna using satellite tagging techniques developed as part of the Popstar project. © Ifremer

Tristan Rouyer and Marine Gonse, researcher and post-doctoral student respectively at Ifremer*, are each participating in a *fish tracking* project to gain a better understanding of fish movements and their behaviour in terms of habitat use, feeding, and reproduction. Popstar uses satellite tagging technology, while Fish Intel uses acoustic telemetry combined with archival tags.

What are the specific features of these two fish marking and tracing programmes?
Marine Gonse

Fish Intel is a European INTERREG project between France, the UK, and Belgium that aims to deploy an acoustic telemetry network in the Channel to gain a better understanding of habitat use and the movements of five target species (blue fin tuna, grey bream, European sea bass, pollack, and red lobster). We fit individuals with acoustic tags that uniquely identify them and emit a signal approximately every 3 minutes. At the same time, we install acoustic receivers that pick up these signals along the coastline to identify the position of the fish and better understand the link between habitats and the presence of these species,

In France, we have also fitted fish with archival tags, DST (Data Storage Tag), which continuously record the surrounding temperature and pressure. Combining these temperature and pressure data with the acoustic detections enables us to correct and refine our fish geolocation models, and thus gain a better understanding of their movements.

Tristan Rouyer

Popstar, which has just come to an end, was a technological project to develop electronic tags with satellite transmissions, known as Pop-Ups. Existing tags are very useful for tracking very large pelagic fish in the open ocean, but they're very expensive (€4,000) and don't provide all the information we need. So the idea was to develop a more economical, smaller brand incorporating a bio-impendance sensor (editor's note: measurement of the resistance of different biological tissues) to monitor changes in the animal's physiology and this better understand the direction of its movements (such as feeding and reproduction).

We were faced purely with technological challenges. Ifremer's Research and Technological Development team and Montpellier's Computer Science, Robotics, and Microelectronics laboratory helped us all with this. But we also has problems marking the fish. We had to catch large spawning tuna while keeping them alive, mark them and allow them to continue on their way. We were able to intervene in the breeding grounds in Malta, then observe the tagged individuals move across the Atlantic to Iceland, and see them return to the Mediterranean a year later.

So are these complementary technologies?
Tristan Rouyer

With Pop-Up Satellite tags, we can track large fish in the open ocean where they spend most of their lives, whereas acoustic telemetry enables more detailed observations over restricted geographical areas, but potentially over longer periods of time (4-5 years). There is also the question of the weight of the sensors. Pop-up tags are heavier and bulkier (60g) and are difficult to fit over the long term on fish that are less than a metre long. Acoustic arrays avoid these limitations.

Where do *Fish Intel* and *Popstar* stand today?
Marine Gonse

Fish Intel is in the take-off phase. A lot of work has gone into setting up the network and tagging the fish. For the project as a whole, 729 fish have been tagged, including around 350 on the French side. More than 200 receivers have also been activated. Initial observations have been encouraging, with around one fish in two having already been located by one of the receivers in just 6 months. As the acoustic tags have an autonomy of 5 or 6 years, we now need to take the time to collect information so that we can carry out analyses of movements and habitat use. We will also have to ensure the maintenance and upkeep of this network, a first in The Channel, by carrying our dedicated or shared expeditions.

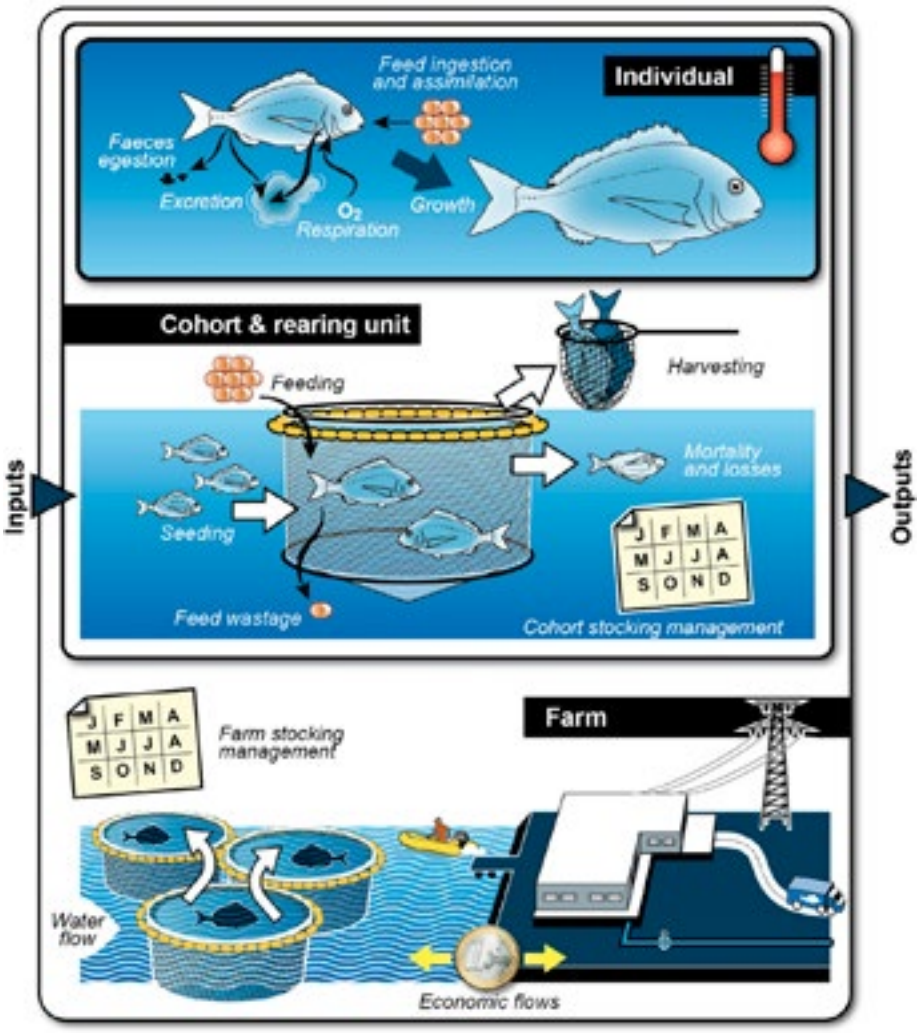
Tristan Rouyer

Popstar has partly achieved its objectives. We have produced prototypes capable of collecting more information and transmitting it. We've also managed to produce beacons at a lower cost. But we haven't yet arrived at the final product that we'd really like to have. We still need to work on transmission and other aspects such as reducing the size. On the other hand, *Popstar*, which was launched in 2016, and officially ended in 2022, has given rise to several other projects on the same topic (*FishnChip*, *Flopped*, *Pompt*, *Release*). We are continuing to develop technologies within this framework. As it's very difficult to obtain quality equipment commercially, this type of work has a major role to play in the future.

It should also be pointed out, for both *Popstar* and *Fish Intel*, that these projects are developed in conjunction with fishermen and professionals in the sector, both in terms of questions and marking. They provide an opportunity for highly rewarding exchanges, as both parties are equally interested in unravelling the mystery of fish movement.

* Tristan Rouyer is a member of the Mediterranean Fisheries Laboratory - UMR *Marine Biodiversity, Exploitation and Conservation* (MARBEC) - and Marine Gonse is part of the Fisheries Biology laboratory - UMR Dynamique et durabilité des écosystèmes: de la source à l'océan (DECOD) -.

State-of-the-art digital models of aquaculture farms



Model of a marine fish farm simulated at three organisational scales: individual, cohort, and farm. © Chary Killian, Brigolin Daniele, Callier Myriam (2022)

As part of an ecosystemic and sustainable approach to aquaculture, a team of scientists has carried out a critical analysis of the main models used to simulate the processes on a fish farm.

In view of the increase in seafood consumption and the decline in wild resources, aquaculture could be required to provide a significant and growing proportion of the world's animal protein supply. With this in mind, the Food and Agriculture Organisation of the United Nations (FAO), with the help of a number of international experts, has drawn up a strategy known as the "ecosystem approach to aquaculture", which aims to ensure both human well'-being and the health of ecosystems. To implement this policy, modelling is a valuable tool that helps translate principles into action. A number of models have already been created, reflecting the biodiversity of farming systems.

As part of the MOCAA project (Modelling Environmental Assimilation Capacity for Sustainable Aquaculture), scientists from Ifremer and other institutions such as the Università IUAV di Venezia, (Daniele Brigolin) and Wageningen University and Research (Killian Chary), have drawn up a state-of-the-art report on the subject by analysing 36 models of aquaculture farms published between 1985 and 2021.

Published in *Reviews in Aquaculture*, their study highlights the main characteristics of these models, lists the modelling techniques used and questions their ability to meet the challenges of marine aquaculture sustainability. Opinions are also expressed on the advances, limitations, and prospects for research into these tools, and on the opportunities for applying them to different fields, such as precision aquaculture, integrated multi-trophic aquaculture, spatial planning, and life-cycle analysis.

This study has been awarded the title of *The Sena De Silver Paper*, which *Reviews In Aquaculture* reserves for high-quality articles.

Chary Killian, Brigolin Daniele, Callier Myriam, *Farm <scale models in fish aquaculture – An overview of methods and applications*, Reviews In Aquaculture, 14(4), 2022. https://onlinelibrary.wiley.com/doi/10.1111/raq.12695

A new edition of the *French Maritime Economic Data* (FMED 2021)

Régis Kaleydjian © Ifremer

Member of Ifremer's Maritime Economics Unit – mixed-research unit Aménagement des Usages des Ressources et des Espaces marins et littoraux (Management of Marine and Coastal Resources and Spaces) (AMURE), Regis Kalaydjian has been leading the production on the economic evaluation of maritime activities since 1997, which is used by many institutional, academic, and economic stakeholders.

What is the purpose of this report?

One of Ifremer's missions is to contribute to the development of the maritime world, and to do this it is necessary to assess its economic weight. The first initiatives date back to 1992–1994 and finally, in 1997, Pierre David, President of Ifremer, commissioned me to produce a formal report to evaluate the French maritime economy, placing it in a global context.

The aim of the FMED is to identify the various activities in the maritime world, analyse them sector by sector, and measure their respective economic weight using a range of indicators (e.g turnover, added value, employment, etc.).

Isn't it difficult to define the scope of the maritime economy?

Yes, but it does pose methodological problems, because the scope can vary greatly depending on the approach chosen. You can consider only strictly maritime activities (fishing, aquaculture, transport, yachting) or include many other related activities. In the FMED, we have chosen a fairly broad approach that takes into account the "strategic suppliers and customers" of maritime activities, such as shipbuilding, the seafood processing industry, the hotel industry, and other services in coastal areas.

How easy is it to find data on these different sectors?

Again, it's not easy, because although national accounting is strict, the breakdown of the French economy does not take account of the marine criterion. So we are often faced with questions of data availability and reliability. For strictly maritime sectors, such as fishing and transport, the situation is fairly straightforward, but for others, such as tourism or the offshore oil and gas industry, it is much more complex, because the coastal nature of the industry is not taken into account in the accounts. What's more, we depend on external sources and are therefore exposed to possible statistical breaks or changes in production methods.

Our expertise lies at this level of research, evaluation, and use of economic data. To compile the FMED, we call on a number of stakeholders (Insee, the French Navy, research institutes, professional organisations, etc.).

What to these FMED 2021 forecasts tell us about economic trends?

We can say that the maritime sector is growing overall and that it has substantially followed the development of the global economy between 2013 and 2019. For example. We don't have all the data we need to assess the Covid-19 effect from 2020 onwards.

An analysis by sector shows that tourism has a huge weight, accounting for just over half of added value and almost two-thirds of employment in the sector. This is followed by three groups, accounting for 6 to 8% of employment and added value: maritime transport (including port and river activities), shipbuilding, which is quite dynamic in the field of liners, yachting, and ship repairs, and a group relating to "seafood products", which includes fishing, aquaculture, and processing industries. There are also some singular activities, such as the offshore oil and gas industry, which is relatively small compared to the rest of the sector in terms of employment, but remains very significant in terms of added value. We should also mention the importance of the public sector (French Navy, research, environmental protection), which accounts for almost 9% of employment.

In the future, we will need to keep a close eye on certain sectors that are currently being developed, such as marine renewable energies (such as offshore wind energy), as well as the development of maritime transport in view of the rising cost of fossil fuels.

10 million data sets acquired by Ifremer on the marine environment open to the public

In line with its commitment to open science, Ifremer has made the data from its monitoring networks available to the public and is launching Surval, an information system designed to make it easier to consult and use.

Making all scientific research data, publications, and source codes accessible by 2030 is a commitment made by the Ministry of Higher Education, Research, and Innovation on 6 July 2021 at the launch of the 2nd national plan for open science. With a view of setting an example in this area, Ifremer has published more than 10 million observation and monitoring data on the marine and coastal environment on the "data.gouv.fr" website. This data covers a range of physical, chemical, and biological parameters (temperature, pH, phytoplankton, viruses and bacteria, fish, waste etc.)

Data from the Rephy (phytoplankton), Remi (viruses and bacteria), Rocch (chemical contaminants) and Ecoscopa (shellfish farming observations) monitoring networks are of interest to scientists, but are also very useful to local authorities, professionals in the shellfish farming sector, consultancy firms, and all those involved in marine water quality.

To make it easier to consult and use the data, Ifremer teams have developed an IT tool called Surval, with user-friendly selection and display functions (maps). The data, which can be consulted by geographical location, can be retrieved in the form of graphical representations and downloaded for use with various software tools.

Visit Surval :
https://www.data.gouv.fr/fr/datasets/surval-donnees-par-parametre/

In line with the commitment to a more open science, Surval is making millions of data points available on the observation and monitoring of the marine and coastal environment.
© Ifremer

Guidance and support

Reducing the Institute's carbon footprint

By carrying out an annual assessment of its greenhouse emissions, Ifremer can identify more clearly where improvements can be made and initiate relevant actions to reduce its carbon footprint.

Combating climate change requires everyone – companies, institutions, and individuals – to make unprecedented efforts to reduce greenhouse gas emissions. The first stage is to measure them. Ifremer is therefore drawing up a greenhouse gas emissions balance sheet (Beges) and a transition plan in line with France's National Low Carbon Strategy. The Institute's first assessment was carried out in 2010, and serves as a benchmark for measuring changes.

Beges divides emissions into three groups, known as "scopes". Scope 1 covers direst emissions by the activity (boilers, for example). Scope 2 includes indirect emissions linked to energy consumption (such as electricity and collective heating etc.). Scope 3 covers other indirect emissions (relating to purchasing, transport, etc.) Beges has become an essential governance tool for guiding the Institute's future strategies in terms of decarbonising current and future activities.

As of 2020, Ifremer included certain scope 3 items (not mandatory at the time) in its balance sheets, in order to better reflect its impacts and anticipate regulations. It has used the Ademe (French Agency for Ecological Transition) carbon base, which converts physical flows (consumption, purchases etc.) into tonnes of CO_2 equivalent (tCO2e). The 2019 and 2021 assessments confirmed the primary scope 3, which generates 94% of the Institute's total emissions (estimated at 56 ktCO2e in 2019). This breakdown reflects Ifremer's special characteristics linked to its research infrastructures, in particular the French Oceanographic Fleet and EuroArgo, and demonstrates the importance of developing a comprehensive and ambitious CSR (Corporate and Social Responsibility) policy.

A number of initiatives have been launched in recent years, including connecting premises to urban heating networks, adjusting the missions policy to encourage the use of low-carbon modes of transport (trains, public transport etc.), and initiating a responsible approach in line with the objectives set by the ministries and eco-responsible public services (SPE). Ifremer has also introduced the principle of eco-design into its technical and scientific projects in order to limit environmental impacts from the start, right from the initial thinking stages.

Quality management: a strong link in the Institute's overall performance

The entire quality team: From left to right: Jean-Marc Sinquin, quality manager for the Brittany Centre, Corinne Floch, quality manager for the North Sea Channel Centre, Marie-Laure Chao, national quality and safety coordinator; José Herlin, quality manager for the Pacific Centre, Audrey Fournier, quality manager for the Mediterranean Centre; Cédric Kergaravat, quality manager for the Atlantic Centre.
© Ifremer - Marie-Helene Bazin

Quality is a core concern for Ifremer and its teams, who work hard every day to implement the quality approach: respecting their commitments, meeting expectations, and increasing the satisfaction of their contacts. In 2022, this quality approach was the subject of several positive evaluations.

Through its evaluations and recommendations, the Haut Conseil d'évaluation de la recherche et de l'enseignement supérieur (Hcéres) accompanies and supports the quality improvement process. In its assessment of Ifremer in 2022, this body highlighted the successful deployment of the quality approach and its role in the Institute's The evaluation report states that Ifremer's quality approach, which is fully integrated into its operational functioning and has been certified for several years, ensures the reliability and traceability of activities, helps to clarify everyone's commitment to the processes, and enables progress to be made without weighing down operations. The assessment committee also emphasised the contribution of the quality system if the Institute's risk management system.

A follow up audit of the ISO 9001 certification was also carried out during the year. It involved teams from seven Ifremer sites for more than five days: Arcachon, La Réunion, New Caledonia, Plouzané, Sète, La Seyne-sur-Mer and Tahiti. The auditors observed a good level of maturity in the quality system. They also noted that its structured approach makes a significant contribution to the Institute's management and provides a real link between strategic decisions and operational activities. The needs for optimisation were also highlighted. As part of the continuous improvement process, these needs will be the focus of particular attention and action in 2023.

The year 2022 also saw Ifremer maintain its ISO 17025 and ISO 17043 accreditations and continue its project to centralise the management of the quality system for its seven accredited laboratories.

Enhanced information systems

Adapting to the intensification of digital users, Ifremer is continuing to improve its collaborative and remote working tools, its administrative data management systems, and its cyber security procedures.

A number of factors, such as remote working and the widespread use of remote collaborative working, have led to a profound change in day-to-day IT and communication needs and practices, As a result, significant investment has been made in upgrading workstations, including the widespread use of laptops, wide-screen monitors and headsets, so that all employees can communicate in better visual and audio conditions via video conferencing. To make the exchange and sharing of documents easier, both internally and with identified, partners, a proprietary cloud-based service is not available, giving access to information from a variety of devices. This cloud is supported by an online shared-editing office suite that enables several people to write and revise documents interactively.

These collaborative solutions add to the electronic diary, webmail, and video conferencing solutions.

Ifremer has also continued its efforts to dematerialise and improve its management procedures. The SIGMA system, which already manages a number of aspects (accounting, finance, purchasing, business travel, human resources, and associated dematerialised procedures), has been extended to include a multi-year programming component for the Institute's activities.

The new features rolled out in 2022 are in line with one of the actions set out in the Contract of Objectives and Performance. They will enable activities, and particular projects, to be monitored throughout their entire life cycle, from the initial idea to its closure, including the updating of budget forecasts and workload plan requests for each action undertaken.

As IT services have become essential to the life of the Institute, it is imperative to ensure their availability and security, particularly in the current context of increasing cyber attacks. A number of measures have therefore been taken to secure and control workstations and servers that run the applications.

For example, in order to keep users as free as possible from unwanted and even harmful emails that flood their mailboxes, a number of filtering devices have been implemented. These filters can be configured by the user (blacklist and whitelist mechanisms) to suit their personal needs and the people they are dealing with. A new anti-virus solution has also been rolled out to all the Institute's workstations and servers in order to deal with new threats.

The DATARMOR supercomputer (located at the Ifremer Brittany Centre), with its impressive data storage capacity and computing power.
© Olivier Dugornay - Ifremer

Human resources and social dialogue

On 31 December 2022, Ifremer had 1,549 employees, including 700 researchers and engineers. Women accounted for 46% of the total workforce. 57 external recruitments were made in 2022.

The implementation of HR development action plan resulted in the launch of two major projects in 2022. The first involves the identification of professions, skills, and their development. The aim of this approach is to draw up an inventory of current professions and skills within our Institute, which will be put into perspective with future strategic activities. Identifying any gaps will enable us to define priorities in terms of managing jobs and career paths, and to draw up an appropriate action plan.

The second project involves Ifremer's managerial model. The aim is to define the skills expected of managers, in order to clarify their tasks and therefore help our employees project their careers into managerial positions. The managerial model will also enable us to harmonise our practices and put into place more specific support for the managerial function. Different work groups have been set up in collective intelligence workshops to inform the thinking of the Management Committee, which will be responsible for defining the managerial model. These two projects will be completed in 2023.

Skills development through training remains a key focus for the Institute. In 2022, 824 employees received training as part of the skills development plan. Managerial support continued with a training module on intergenerational management. Finally, Ifremer continued to develop its policy of taking on people on work-study contracts by recruiting 72 new employees on apprenticeship or professional training contracts.

In terms of social dialogue, 2022 was marked by the signing of an agreement on professional equality between men and women and quality of life at work. In addition, an agreement was signed in 2022 on staff representation bodies within the framework of the social and economic committee, an agreement on the number and composition of electoral colleges and an election of staff representatives to the scientific community.

It should also be noted that negotiations to update the company agreement continued. Around ten meetings were held between management and trade unions representatives on this subject.

In 2022, with the aim to strengthen its measures to combat sexual harassment and sexist behaviour, Ifremer organised an awareness-raising session for all staff and a training programme for managers. On 25 November 2022, the International Day for the Elimination of Violence against Women, a conference was organised for all employees on this subject.

The "*On ne peut plus rien dire*" ("*We can't say anything anymore*") seminar, aimed at understanding and deconstructing the main objections to the fight against sexism, was given by an external speaker specialising in these issues.

Ifremer wanted to introduce a regular, renewable survey to measure changes in the quality of life at work for the Institute's staff. The first survey of this "quality of life at work" indicator took place from 20 to 27 June 2022 during the national Quality of Life at Work week. The results of this survey, to which 50% of employees responded, were published on the Institute's Intranet.

Budgeting and financial data

See point 3 of the Board of directors report: End-of-year accounts

BALANCE SHEET	2022 Earnings	Amortisations and depreciations	2022 Net	2021 Net
FIXED ASSET				
Intangible assets	59 374 156,52	44 200 993,87	15 173 162,65	15 226 004,50
Tangible assets	645 228 414,44	447 163 939,41	198 064 475,03	198 224 623,93
Sites	6 776 232,47	2 072 800,41	4 703 432,06	6 767 609,06
Buildings	119 404 800,79	79 106 611,79	40 298 189,00	39 032 801,00
Technical installations, equipment, and tools	418 758 357,29	331 078 034,29	87 680 323,00	92 836 683,00
Collections	861 392,32	0,00	861 392,32	872 856,49
Historical and cultural goods	0,00	0,00	0,00	0,00
Other tangible assets	44 104 942,92	34 906 492,92	9 198 450,00	8 528 096,58
Concession assets	0,00	0,00	0,00	0,00
Fixed assets under construction	630 956,92	0,00	630 956,92	622 426,08
Advances and deposits on order	54 691 731,73	0,00	54 691 731,73	49 564 151,72
Assets encumbered with rights	0,00	0,00	0,00	0,00
Tangible assets (living assets)	0,00	0,00	0,00	0,00
Financial assets	20 750 034,16	356 365,73	20 393 668,43	20 554 228,97
TOTAL FIXED ASSETS	**725 352 605,12**	**491 721 299,01**	**233 631 306,11**	**234 004 857,40**
CURRENT ASSETS				
Stocks	0,00	0,00	0,00	0,00
Receivables	72 392 400,32	378 797,17	72 013 603,15	63 752 965,28
Receivables on public entities (E.g, State, other public entities) of international bodies and the European Commission	51 088 508,65	0,00	51 088 508,65	49 312 726,80
Client receivables and related accounts	7 132 359,41	378 797,17	6 753 562,24	6 756 704,63
Receivables from debts (earmarked tax income)	0,00	0,00	0,00	0,00
Advanced payments and deposits on orders	2 085 519,70	0,00	2 085 519,70	953 064,34
Receivables corresponding to transactions on behalf of third parties (intervention schemes)	0,00	0,00	0,00	0,00
Receivables from other debtors	12 086 012,56	0,00	12 086 012,56	6 730 469,51
Prepaid expenses	0,00	0,00	0,00	20 745,82
TOTAL CURRENT ASSETS	**72 392 400,32**	**378 797,17**	**72 013 603,15**	**63 773 711,10**
TREASURY				
Marketable securities	0,00	0,00	0,00	0,00
Cash and cash equivalents	153 915 058,91	0,00	153 915 058,91	107 517 483,93
Other	0,00	0,00	0,00	0,00
TOTAL TREASURY	**153 915 058,91**	**0,00**	**153 915 058,91**	**107 517 483,93**
Adjustment accounts	0,00	0,00	0,00	0,00
Unrealised exchange losses	0,00	0,00	0,00	0,00
GENERAL TOTAL	**951 660 064,35**	**492 100 096,18**	**459 559 968,17**	**405 296 052,43**

LIABILITIES BALANCE SHEET	2022	2021
EQUITY		
Funding received	142 344 675,51	155 186 148,78
Funding from State assets	97 358 065,30	104 534 680,49
Funding from third party assets	37 141 736,21	36 496 033,31
Equity from foundations	0,00	0,00
Revaluation surplus	7 844 874,00	14 155 434,98
Reserves	131 587 380,57	125 276 819,59
Retained earnings	14 602 098,69	18 688 977,64
Profit/loss for the financial year	14 819 017,81	-2 809 281,72
Regulated provisions	0,00	0,00
TOTAL EQUITY	**303 353 172,58**	**296 342 664,29**
PROVISIONS FOR RISKS AND COSTS		
Provisions for risks	2 635 902,03	3 170 194,53
Provisions for costs	37 683 384,00	35 443 240,45
TOTAL PROVISIONS FOR RISKS AND COSTS	**40 319 286,03**	**38 613 434,98**
FINANCIAL DEBTS		
Bonds	0,00	0,00
Loans taken out with financial institutions	0,00	0,00
Financial debts and other loans	0,00	0,00
TOTAL FINANCIAL DEBTS	**0,00**	**0,00**
NON-FINANCIAL DEBTS		
Debts to suppliers and related accounts	18 405 761,55	12 462 534,66
Fiscal and social debts	36 751 314,51	28 115 568,45
Received advanced payments and instalments	56 189 353,60	28 198 166,79
Debts corresponding to transactions on behalf of third parties (intervention schemes)	0,00	0,00
Other non financial debts	3 468 006,61	906 868,92
Deferred income	992 094,16	656 390,00
TOTAL NON-FINANCIAL DEBT	**115 806 530,43**	**70 339 528,82**
TREASORY		
Other elements of cash liabilities	80 979,13	424,34
TOTAL TREASURY	**80 979,13**	**424,34**
Adjustment accounts	0,00	0,00
Unrealised exchange losses Liabilities	0,00	0,00
GENERAL TOTAL	**459 559 968,17**	**405 296 052,43**

Income statement

CHARGES	2022	2021
ADMINISTRATION COSTS		
Purchases	0,00	0,00
Consumption of goods and supplies, performance of work and direct consumption of services by the organisation in the course of its business, as well as expenses relating to changes in stocks	112 042 385,99	104 230 398,80
Staff costs	102 317 923,17	100 009 398,29
Wage, salaries, and various remunerations	69 985 802,91	68 112 108,06
Social contributions	26 686 071,47	26 701 117,65
Profit sharing and participation	0,00	0,00
Other staff charges	5 646 048,79	5 196 172,58
Other administration costs	12 945 038,37	12 761 136,62
Funding for amortisations, depreciations, provisions, and net book value of assets sold	33 198 715,50	23 202 583,11
TOTAL ADMINISTRATION COSTS	260 504 063,03	240 203 516,82
BANK FEES		
Intervention system for own account	38 036,43	24 500,00
Transfers to households	0,00	0,00
Transfers to businesses	0,00	0,00
Transfers to territorial collectivities	0,00	0,00
Transfers to other entities	38 036,43	24 500,00
Charges resulting from the application of the body's guarantee	0,00	0,00
Funding for provisions and depreciations	0,00	0,00
TOTAL FEES FOR INTERVENTION	38 036,43	24 500,00
TOTAL MANAGEMENT AND INTERVENTION COSTS	260 542 099,46	240 228 016,82
FINANCIAL COSTS		
Interest costs	0,00	645,00
Net costs of transfers of marketable securities	0,00	0,00
Exchange losses	11 271,11	22 939,85
Other financial costs	0,00	0,00
Funding for amortisations, depreciations, and financial provisions	2 422,00	353 037,11
TOTAL FINANCIAL COSTS	13 693,11	376 621,96
Corporate tax	626 200,00	-162 937,00
INCOME FROM ACTIVITIES (PROFIT)	14 819 017,81	0,00
TOTAL COSTS	276 001 010,38	240 441 701,78

INCOME	2022	2021
OPERATING INCOME		
Non-cash income (or grants and similar income)	221 264 699,39	209 365 138,72
Grants for public service costs	181 040 100,00	175 639 074,00
Operating grants from the State and other public entities	40 224 599,39	33 726 064,72
Grants specifically allocated to fund certain intervention costs from the State and public entities	0,00	0,00
Donations and legacies	0,00	0,00
Earmarked tax income	0,00	0,00
Direct counterparty revenues (or direct business revenues)	37 391 328,17	14 049 889,37
Sales of goods or services	14 547 484,68	12 297 968,27
Income from disposal of assets	21 586 452,59	23 006,61
Other management income	1 257 390,90	1 728 914,49
Stocked and fixed-asset production	0,00	0,00
Other products	16 964 281,22	14 194 031,03
Reversals of amortisations, depreciations, and provisions (operating income)	1 409 847,52	1 617 929,56
Reversal of asset financing	15 554 433,70	12 576 101,47
TOTAL OPERATING INCOME	275 620 308,78	237 609 059,12
FINANCIAL INCOME		
Income from investments and loans	20 795,88	15 733,08
Interest from unfixed receivables	0,00	0,00
Income from marketable securities and the treasury	0,00	0,00
Net income from the transfer of marketable securities	0,00	0,00
Exchange gains	16 195,73	7 627,86
Other financial income	0,00	0,00
Reversal of amortisations, depreciations, and financial provisions	343 709,99	0,00
TOTAL FINANCIAL INCOME	380 701,60	23 360,94
INCOME FROM ACTIVITIES (LOSS)	0,00	2 809 281,72
TOTAL INCOME	276 001 010,38	240 441 701,78

Governance and organisation

Board of Directors

President
François HOULLIER, President – General manager

State Representatives
Ministry of Higher Education, Research, and Innovation
Mrs Lise FECHNER, full member
Mr Didier MAEQUER, acting member

Ministry for the Sea
Mr. Thierry COURTINE, full member
Mrs. Marie FEUCHER, acting member

Ministry of Maritime Fisheries and Marine Cultures
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Mr. Julien LAMOTHE
Mr. Frédéric MONCANY DE SAINT-AIGNAN

For living resources
Mrs. Elsa CORTIJO
Mrs. Valérie VERDIER

Elected representative of Ifremer staff
French Democratic Confederation of Labour
Mrs. Catherine TREGUIER
Mr. Loïc LE DEAN
Mrs. Marie-Anne CAMBON BONAVITA
Mr. Abdellah BENABDELMOUNA

General Confederation of Labour
Mr. Eric ABADIE
Mrs. Carla SCALABRIN
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Members with an advisory capacity
Government Commissioner
Vincent MOTYKA

General Secretary of the Sea
Denis ROBIN
Patrick AUGIER, full member

General Economic and Financial Control
Philippe DEBET

Ministry for Overseas France
Camille SERVETTO

Chairman of Ifremer's Scientific Committee
Patrick LANDAIS

Ifremer's main accounting officer
Didier JAOUEN

Scientific Committee

Requested to comment on the Institute's scientific and technological programes, the Scientific Committee focused in 2022 on the Hcéres evaluation, the launch of the Blue Chair in Nantes and the preparation of the next contract of objectives, resources, and performance.

In line with its mission, the Scientific Committee supported Ifremer throughout 2022, at three regular meetings (March, June, November) and in working groups that issued opinions on a number of topics.

The Committee was involved at several stages in the Ifremer self-assessment report submitted to the Haut Conseil d'évaluation de la recherche et de l'enseignement supérieur (Hcéres). It seemed essential that the Committee be asked to support this five-year review (2016-2020), which is dedicated to assessing achievements and identifying areas for improvements.

2022 was also marked by the creation of the first Blue Chair based in Nantes, which will run a five-year research project on the subject of "Contaminants, the Sea, and Health". The Scientific Committee monitored the entire process of setting up the chair, from the development of the subject, to the recruitment of the candidate. Feedback was drawn up an analysed jointly with the entire Committee.

In addition, to help the Institute implement the next Contract of Objectives, Resources, and Performance (CORP) as effectively as possible, the Scientific Committee provided its expertise on high-stakes themes such as Carnot MERS, the Ocean-Climate Priority Research Programme and Equipment, and making constructive recommendations.

In general, the Committee is always willing to listen to candidates for European Research Projects (ERC) and to pass on any comments that could be of benefit to both the project leader and Ifremer.

Members of the Scientific Committee

President
- Patrick LANDAIS

Members appointed by Order
- Denis ALLEMAND
- Anne BEAUVAL
- Gérard BLANCHARD
- Chris BOWLER
- Pascale BRACONNOT
- Annie CUDENNEC
- Jean-François GHIGLIONE
- Anne-Marie GUE
- Gonéri LE COZANNET
- Edwige QUILLET
- Hervé ROQUET
- Frédérique VIARD

Members representing Ifremer staff
- Jean-François PEPIN ;
  Acting member Marie-Anne CAMBON BONAVITA
- Caroline MONTAGNANI ;
  Acting member Christophe DESBOIS
- Julien NORMAND ;
  Acting member Ricardo DA SILVA JACINTO

Permanent guests
- Nicolas ARNAUD
- Didier GASCUEL
- François LALLIER
- Frédéric MENARD
- Sylvie REBUFFAT

Ethics in Common Committee

Renamed "Ethics in Common", the Committee has set up a dedicated website, organised a day of exchanges in homage to Axel Kahn, and continued its work on reflecting on several subjects relating to human needs, natural resources, and the preservation of the biosphere.

In 2016, Ifremer joined the Ethics in Common Committee of the Institut national de recherche pour l'agriculture (Inra, became Inrae) et au Centre de coopération internationale en recherche agronomique (Cirad), which at the end of 2019, with the integration of the Institut de recherche pour le développement (IRD), the Inrae-Cirad-Ifremer-IRD joint advisory committee. This committee provides the four organisations with an independent framework for reflection on the ethical and societal consequences of their research activities.

Following the sudden death of Axel Kahn in July 2021, who had begun his second term as chairman of the committee a few months earlier, Michel Badré and Bernadette Bensaude-Vincent were appointed chairman and vice-chairman of the Ethics Committee in November 2021. Both have worked to continue the momentum that Axel Kahn wanted to give to the committee: to be more attentive to the ethical expectations and questions of the staff of the four research organisations and to share the committee's more widely with the general public in order to provide food for thought on the major issues for society. For this reason, in 2022, the Committee, renamed Inrae-Cirad-Ifremer-IRD Ethics in Common, has set up a new dedicated website, through which the staff of the organisations can communicate with its members and chair, and consult the various opinions issued. In addition to these web-based exchanges, on 23 September 2022 the members of the Ethics in Common Committee, together with the presidents of the four research organisations and invited scientists, took part in a day-long event in Paris in tribute to Axel Kahn. Bringing together around 140 participants in person or in distant, this event was an opportunity to stimulate reflection on the ethical dimensions of scientific activities in the service of society, and to encourage exchanges between committee members and scientists from the organisations.

In 2022, the Ethics in Common Committee issued two new opinions relating to human needs, natural resources, and the preservation of the biosphere: one on pollution and competing uses of water, the other on agricultural practices and soil quality, The committee has also begun work on a new referral on the exploration, use, and preservation of unknown environments with very low levels of human activities. The deep seabed will be at the heart of this referral. Finally, Ifremer has responded to opinions 11 and 12 on the editing of animal and plant genomes, which can be accessed on the Ifremer Intranet site.

Discover the committee's website and activities:
https://www.ethique-en-commun.org
English version https://www.ethique-en-commun.org/en

Members of the Ethics in Common Committee

Michel BADRÉ, president of the Committee.
Bernadette BENSAUDE-VINCENT, vice-president of the Committee.
Madeleine AKRICH
Catherine BOYEN
Bernard BRET
Denis COUVET
Mireille DOSSO
Mark HUNYADI
Paula MARTINHO DA SILVA
Marie-Geneviève PINSART
Pere PUIGDOMENECH
Ricardo SERRÃO SANTOS
Youba SOKONA
Laurent THÉVENOT

Stakeholders Committee

In the first year of operation, the committee looked at ways of developing participatory research and involving certain stakeholders more closely in the research process.

The creation of the Stakeholder Committee (CPP) is part of a global movement to bring the world of research and society closer together. The strategic priority for the Institute was formalised by the signing of a "charter for openness to society" in 2020 involving 7 other research and expertise establishments. The CPP is a tool for regular, in-depth dialogue with the public, in addition to the stakeholders already involved.

To gain a better understanding of societal issues and Ifremer's research, the 23 members of this new body set out to meet stakeholders and Ifremer employees. For their first working sessions in 2022, they held their plenary meetings at various Ifremer sites (Plouzané, Paris, Nantes) and at the shellfish trade fair in Vannes.

At their first meeting, the Committee initiated a discussion on the results of the Starfish 2030 survey (a consultation of European citizens on the future of the ocean and aquatic system). The aim was to assess the relevance of this type of dialogue with society and the possibility of translating the public's expectations into Ifremer's research. The high response rate, demonstrating the public's ability to engage with these issues, makes this a very interesting experiment. Can we sustain this type of survey over time? Can it be used both as a measurement and a means of communication, to monitor people's knowledge and the effectiveness of certain initiatives? The Committee has made a number of recommendations. It recommends defining target groups with whom to organise dialogue, using networks that are not solely socio-professional. It also recommends working with researchers to develop a methodology for implementing participatory research, and to consider whether stakeholders should be involved at every stage of the research project.

As part of a referral, the Committee also considered the position expected of a scientific and technical organisation such as Ifremer in the implementation of European marine directives, in particular the Marine Strategy Framework Directive. A work group was set up and conducted a series of hearings with stakeholders involved in putting this directive into practice. A collective decision was made in July, clarifying Ifremer's position in the general implications of this directive and making recommendations, such as ownership by stakeholders of the work resulting from the directive, practices in terms of expertise, the need to strengthen the exchange of knowledge, and access and data development approaches. Finally, the committee emphasised the need to strengthen the Institute's organisation in terms of assessment and monitoring in support of public policy.

In September, in response to another referral, a new work group was set up to address the question: "What kind of research is needed to develop sustainable and innovative marine aquaculture: issues and stakeholder expectations". The committee will submit its response by the end of the end of the first half of 2023.

Members of the CPP

Co-presidents
- Geneviève PONS
- Sébastien TREYER

Association of Charities and NGOs
- Laurent DEBAS
- Raphaëla LE GOUVELLO
- Céline LIRET
- Jean-Yves PIRIOU
- Christophe SIRUGUE

Association of Maritime Companies and Craftspeople
- Laurent CASTAING
- Anne GUILLAUMIN GAUTHIER
- Sarah LELONG
- Alexandre LUCZKIEWICZ
- Stéphane Alain RIOU

Association of Maritime Workers
- Thierry LE GUEVEL
- Marie-Noëlle TINE DYEVRE

Association of Elected Representatives and Regional
- Gil BERNARDI
- François GATEL
- Michel GOURTAY
- Stéphane HAUSSOULIER
- Gaël LE MEUR
- Patricia TELLE

Association of Involved Citizens
- Marion BOURHIS
- David GUILLERME
- Simon RONDEAU

Central Social and Economic Committee (CSE-C)

Anne Boisseaux, elected secretary of the Central Social and Economic Committee (CES-C). © Ifremer

The CSE-C is a staff representative body that examines the operation and general development of Ifremer and Genavir, issuing opinions on its management and direction. Anne Boisseaux, its elected secretary, explains the organisation and tasks of this body, its role in discussions with management and the topics it will be issuing in 2022.

Could you describe the CSE-C, its role, and how its organised?

The Central CSE, as its name suggests, deals with the economic and social unit (ESU), i.e the global issues that concern all the facilities. It is made up of elected representatives from each of the CSEs and the Pacific Work Council (PWC). It has 20 full members and 20 Substitute members, distributed in proportion to the number of employees at each site.

Ifremer's CEO heads the CES-C which meets three times a year under the terms of the company's Articles of Association, but may also hold additional meetings at the request of management or elected representatives. Its role is to issue opinions on the running of the Ifremer-Genavir ESU, reflecting the concerns of staff.

What subjects does the CSE-C deal with?

The CSE-C examines the economic and financial situation, strategic directions, and various subjects of interest to employees. Specialised committees (economic, training, professional equality, housing, health, and welfare) prepare the decisions of the CSE-C on the company's social policy, training and employment initiatives, the choice of health and welfare service providers, the management of the 1% housing fund, and so on. A central "health, safety, and working conditions" committee (CSSCT-C), an offshoot of the CSSCTs specific to each facility, is involved in cross-company issues. To draft its opinions on the economic and financial situation, the CSE-C is assisted by a firm of chartered accountants who analyse the Ifremer-Genavir accounts. The CSE-C has three employees who manage the holiday grants scheme in particular. In 2022, 839 applications were processed for 1,600 children, representing a total amount of €465,000. Total allocations (all CSEs combined) amounted to €1.3m in 2022.

In addition to raising employees' concerns with management, the CSE-C is also responsible for keeping all staff informed. Minutes are drawn up for each meeting and approved by all members. As the time taken to draw up and validate the minutes is long, a brief summary is drawn up at the end of each meeting and sent to all employees.

What are the main opinions expressed in 2022?

The elected representatives acknowledged that the financial situation was healthy and that budgetary control was being strengthened from year to year. Despite this, they expressed concern about the deficit in 2021 (€2.8m) and the 2022 budget (voted at €-5.1m). Insufficient funding could hinder job growth. They see the future as highly uncertain in terms of funding the wage bill and maintaining staff numbers. They also consider that the high level of temporary employment (21.2% of total employment) has reached its limits. They did, however, point out some positive developments, such as improved recruitment processes at Ifremer and increased recruitment at Genavir.

In the area of strategic directions, the elected representatives agree with some of the evaluation report published by the Haut Conseil d'évaluation de la recherche et de l'enseignement supérieur (Hcéres). They noted the recognition of Ifremer's skills and its good image, both internationally and in the French maritime world, but emphasised the gap between its ambitions and its resources. The CSE-C made a number of recommendations aimed at balancing resources and expenditure. It also called for a better definition of Ifremer-Genavir's partnership strategy and role in the national research and innovation system, ideally as part of a co-construction approach.

The CSE-C Office

Secretary	Anne BOISSEAUX
Treasurer	Marine SALAÜN
Assistant secretary	Fabrice GUÉGAN
Assistant treasurer	Sandrine BONNETOT

CSE-C Elected Representatives

Centres

Full members	Michel BOUTBIEN	CFDT
	Jean-Bernard DONOU	CFDT
	Fabrice GUÉGAN	CFDT
Substitute members	Christine DUBREUIL	CFDT
	Sylvie LE GUEN	CFDT
	Stéphane GUIOMAR	CFDT

Brittany

Full members	Yannick PÉRON	CGT
	Emmanuel RINNERT	CFDT
	Marine SALAÜN-GRALL	CFDT
	Sylvie VAN ISEGHEM	CFDT
	Anne BOISSEAUX	CFDT
Substitute members	Laure QUINTRIC	CFDT
	Gilles CAVAREC	CFDT
	Lucile DURAND	CFDT
	Rémi MONGRUEL	CGT
	Anne BOIRON-LEROY	CFDT

Atlantic

Full members	Sandrine BONNETOT	CFDT
	Morgan LE MOIGNE	CGT
	Audrey FOURNIER	CFDT
Substitute members	Erwann MANAC'H	CFDT
	Véronique VERREZ-BAGNIS	CFDT
	Patrick CHEILAN	CFDT

Mediterranean

Full members	Jibril DIFALLAH	CFDT
	Patrice LUBIN	CFDT
Substitute members	Rémi SUDA	CFDT
	Élodie TORNATO	CFDT

North Sea Channel

Full members	Frank JACQUELINE	CGT
	Julien NORMAND	CGT
Substitute members	Vincent DUQUESNE	CGT
	Wilfried LOUIS	CGT

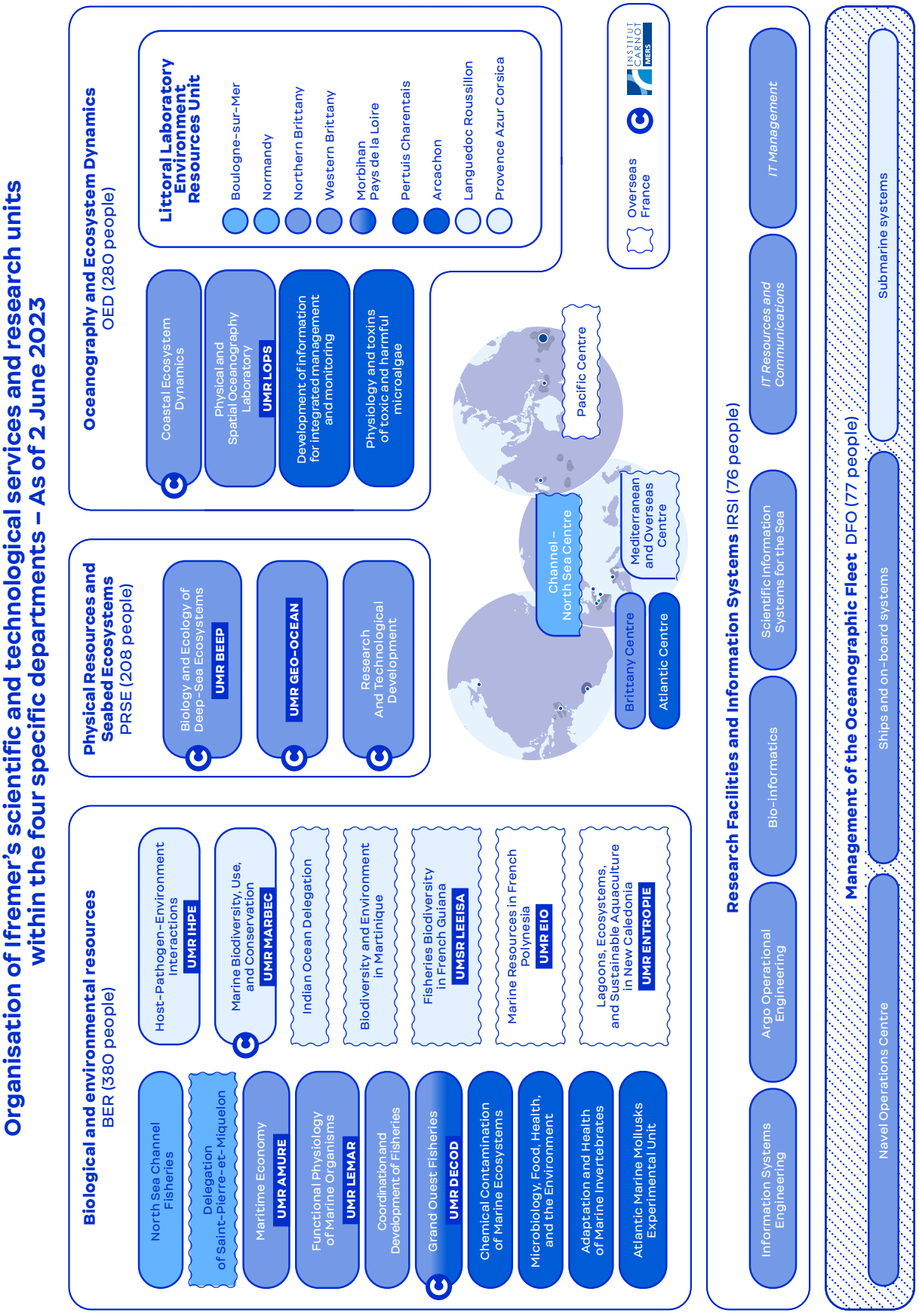
Tahiti / New Caledonia

Full members	Dominique PHAM	Usoenc/CFDT
	Loïc PRIEUR	A Tia I Mua/CFDT
	Philippe SCHNEIDER	CGT
Substitute members	Hermann AURENTZ	A Tia I Mua/CFDT
	José HERLIN	Usoenc/CFDT
	Pascal DELPIERRE	CGT

Genavir Sailors

Full members	José REBELO	CGT
	Brice CELERIER	CGT
Substitute members	Madjid BOUAYAD-AGHA	CGT
	Pierre SAMUEL	CGT

Organisation of research and research support facilities



Organisational chart as of 1 July 2023

Security and defense officer
Vincent Rigaud

Delegate for professional conduct and scientific integrity
Marianne Alunno-Bruscia

Delegate for data protection (gdpr) sd-csr
Jean-Marc Sinquin

National quality and safety coordinator
Marie-Laure Chao

François Houllier
Chairman & chief executive officer

Patrick Vincent
Deputy General Manager

Head of accounting
Didier Jaouen

Genavir
Éric Derrien (CEO)

Institut Carnot Mers
Jean-Marc Daniel (director)

5 Centers in the three major oceans

Channel – North Sea
Benoist Hitier (interim)

Brittany
Valérie Mazauric

Atlantic
Yvan Guiton

Mediterranean
Vincent Rigaud

Pacific
Philippe Moal

Scientific director
Chantal Compère

Coordinator for expertise in support of public policy
Olivier Le Pivert

Director Technology Transfer and Innovation
Romain Charraudeau

Department of biological resources and environment
Tristan Renault
• 16 units

Department of physical resources and seafloor ecosystems
Jean-Marc Daniel
• 3 units

Department of oceanography and ecosystem dynamics
Philippe Riou
• 3 units
and 1 subdivision

Department of research infrastructures and information systems
Gilbert Maudire • 6 units and subdivisions

Oceanographic fleet division
Olivier Lefort • 2 units and 1 subdivision

European and international affairs division
Natalia Martin Palenzuela

Communication and institutional relations division
Géraldine Guillevic

Human resources division
Elisabeth Etcheverry

Administrative, legal and financial division
Laurent Couret

Colophon

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Our thanks to every one who contributed to this annual report.

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FRANÇAISE
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Fraternité

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Commercial Organisation

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